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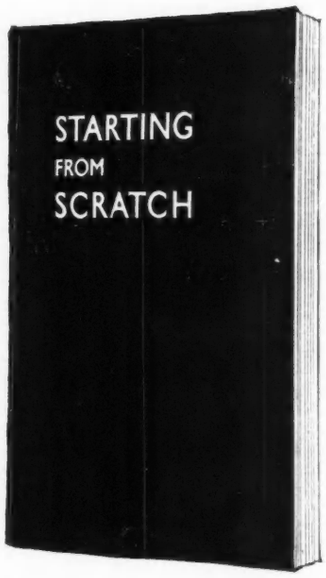

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THE STORY OF ATOMIC ENERGY.

II.—THE MODERN ATOMIC AND MOLECULAR THEORIES.

By Dr. Frederick Soddy, F.R.S.*

The simple laws of chemical combination give what are termed the chemical equivalents—or relative proportions by weight in which all the elements unite to form compounds with one another—as purely experimental constants, to which the relative weights of their atoms must be integrally related, in accordance with the unknown numbers of the different kinds of atoms constituting the compound. For example, using capital letters as symbols for the atoms, the equivalent of oxygen in terms of that of hydrogen as unity being 8, if water is HO, the atomic weight of oxygen is 8 when that of hydrogen is unity. If it be, as it is, H_2O, the atomic weight of oxygen is 16, and so on. It was this unknown that alone introduced uncertainty, and until the Periodic Law was discovered in the latter third of last century, a certain measure of hypothesis still lingered in the chemical atomic theory, so that almost up to the end of it some analysts refused to use atomic weights, preferring formulæ expressed by chemical equivalents, as HO for water, not H_2O.

A more important reason for the long time taken for the atomic theory to reach the position of an unchallengeable law rather than a puzzling hypothesis, was that, as in the Eighteenth Century, there were two separate theories attempting to establish themselves at the same time, for long without any very clear understanding by chemists and physicists of their precise relation: a chemical and a physical theory. They are now termed the Atomic Theory and the Molecular Theory, respectively, though the latter was still called the Atomic Theory by physicists at the beginning of this century. Thus, Sir Arthur Rücker's presidential address to the British Association in 1901 bears this title, but has not one word in it referring to atoms as that term is now universally understood. Because chemical change is more fundamental than physical change, the atom is, and has always been, easy to define as the indivisible unit particle of an element participating in chemical changes and exchanges. The molecule, on the other hand, cannot any longer be, even mentally, connected with the idea of subdivision, as the ultimate particle of a compound substance, or "compound atom," as it was first termed. This was an ultimate particle in the sense that, by further division of it, the compound would be broken up into its constituent elements, and cease to exist as such. The term molecule is still frequently used in that rather loose sense; but the modern definition of the molecule is rather the opposite of that of the atom, in that it is the actual particle of matter having separate or free continuous existence. This applies equally whether it is a compound atom as above defined, in the gaseous or liquid state, a microscopic particle freely suspended in a liquid emulsion, a mote floating in a sunbeam, or a constituent particle of a nebula. Indeed, by strict definition, the universe of separate stars is, not at all fancifully, often regarded by astronomers as a collection of molecules. This is, in fact, at bottom, a new conception not really connected at all with the idea of the subdivision, or atomicity of matter, but resulting from the so-called law of equipartition of energy, only much later recognised. The molecule is a purely experimental particle, once that law is accepted as true. But at first it was not understood that the so-called "atoms" of the common elementary gases, no more than those of the compound gases, can exist free. These gaseous elements exist in the form of compound atoms, or molecules, in which two or more similar atoms are combined. The chemical inertness of gaseous nitrogen is to be ascribed to the atoms of that element preferring union with one another, rather than with any different kinds of atoms. Modern high explosives have molecules in which nitrogen as single atoms is combined with atoms of carbon and oxygen, and their detonating power is due to this preference of the nitrogen atoms to unite with one another, resolving the solid compound into an intensely heated mixture of gaseous nitrogen and oxides of carbon.

Though the atomic and molecular theories have now a completely independent theoretical basis, at first they were inextricably linked together. The determination of what multiple of the chemical equivalent to take for the atomic weight awaited the discovery of methods of determining the molecular weight, withal for this purpose a very rough determination suffices. By determining the molecular weight of as many of the compounds of the element as possible, in terms of that of hydrogen, H_2, as 2, or oxygen, O_2, as 32, the atomic weight could be taken as the *least* weight of the element present in the molecular weights of the various compounds, in the confident hope and presumption that at least in one, at any rate, of these compounds there existed only one atom of the element in the molecule. As a matter of fact no errors arose through this remaining assumption, though complete certainty awaited the discovery of the non-valent Group O elements at the end of last century.

Fig. 5. John Dalton, 1766-1844.

The Actual Emergence of the Atomic Theory.

To begin at the beginning, the first recognition of chemical equivalents was by J. B. Richter (1762-1807), a German chemist and mining official, to whom we owe the illuminating if cacophonous term, Stöchiometry, now almost obsolete, which is regrettable as it is good Greek for "the measurement of what cannot be further subdivided." His *Rudiments of Stöchiometry* was published in 1792-94. To him, equivalents meant the relative weight-proportions in which bases and acids unite. These purely experimental researches undoubtedly established, for these substances, the first law of chemical combination, that chemical union occurs by constant weight-proportions, and in two cases that the same substances may unite in two different proportions. But, partly because of his obscure phlogistonist language, and partly on account of other generalisations he attempted being wrong, the magnitude of his contribution was unrecognised at first, and it did not influence the emergence of the chemical atomic theory.

The immediate forerunner was the celebrated controversy between two French chemists, Proust and Berthollet, 1799-1807, as to whether the composition of a chemical compound was invariable, or whether it contained more of that element in excess during its formation. Berthollet maintained the latter, but the former, which was Proust's view, was ultimately established. The latter also found, as Richter had for acids and bases, that when more than one compound of the same two elements exists, the proportions vary step-wise, not gradually; but he just missed the Law of Multiple Proportions. For example, he found, for the two oxides of tin, approximate percentage proportions 89 : 11 and 75 : 25, respectively, but did not notice that, per unit weight of oxygen, the weight of tin is approximately 8 and 4, respectively.

Dalton and the Atomic Theory.

As hitherto thought, the Atomic Theory of the Nineteenth Century was first put forward by John Dalton (1766-1844), whose portrait* is reproduced in Fig. 5, on this page. It was characterised and distinguished from its predecessors by the weight of the atom being the criterion by which it was recognised and traced, but the general belief, held till the closing years of that century, that it was put forward to account for the Law of Multiple Proportions, is the inverse of the truth.† Dalton discovered that law as a necessary consequence of any such atomic theory. His two famous criteria, that all the atoms of the same element have the same atomic weight, and that those of different elements have different weights, were both specious merely, and are now known to be fundamentally false; whereas, it is interesting to note, in associating the properties of matter with the shape and size of the constituent atoms, the Greeks were, on present knowledge, right.

On October 21, 1803, Dalton communicated orally to a meeting attended by nine members of the Literary and Philosophical Society of Manchester, of which he was the secretary, a paper entitled "On the Absorption of Gases by Water and other Liquids." At the conclusion of it, he raised the question why the solubilities were not the same for all gases, and expressed himself "nearly persuaded" that it depended on the weight and number of their ultimate particles, "those whose particles are lightest and single being least absorbable, and the others more as they increase in weight and complexity." Without explaining how he obtained them, he ends with a table of relative weights of the ultimate particles. The paper was not published till over two years later and then this table contained 21 substances, but the evidence is that it had been added to in the meantime.

Like Lavoisier, Dalton was, by preference, interested in physics rather than chemistry, and only took up the latter as a consequence of his work in the former. His first book was on meteorology, having been written before he went, in 1793, to a Manchester college as a mathematics and physics master, and this subject remained a favourite one with him all his life. He was attempting to apply an atomic theory to the purely physical properties of gases, and seems to have been surprised to find that the gases differed in their solubility. An ardent believer in Newton's atoms, he was especially interested in trying to solve a meteorological conundrum, put forward first by Priestley, as to how the atmosphere, consisting as it does of gases of differing specific gravity, could remain homogeneous, without the oxygen sinking to the bottom and the nitrogen floating to the top. Newton's atoms were supposed to consist, so far as concerned gases or "elastic fluids," of superlatively hard separate small particles endowed with the power of mutual repulsion, the repulsive force between them increasing in proportion as the distance apart diminishes. Dalton, in conformity with the fashion of the times, no doubt influenced by the views of Lavoisier, somewhat more definitely regarded them as consisting of an exceedingly small hard central nucleus surrounded by an enormously more bulky atmosphere of heat, growing gradually rarer outwards. The elasticity of gases was ascribed to these atmospheres mutually repelling one another, so that by increasing the heat the density of the gas is diminished. On any such view of atoms, gases are static structures, rather than, as now taught in the kinetic theory of gases and the dynamical theory of heat, an assemblage of swiftly moving molecules diffusing and expanding to fill the space available, not by their mutual repulsions, but by their perpetual motion. Such forces as occur between molecules are, of course, the attractive, not repulsive, forces causing liquefaction ultimately as their kinetic energy is reduced. But Dalton, wrestling with this problem, insoluble with the Newtonian type of atom, actually likened the structure of gases to that of a square pile of shot!

* We have arranged with Dr. Soddy to publish his new book, *The Story of Atomic Energy*, in the form of a series of articles which will appear at fortnightly intervals approximately. Dr. Soddy, however, retains the copyright; therefore no extract may be made from these articles without his permission.—Ed. E.

* From *A New View of the Origin of Dalton's Atomic Theory*, by H. E. Roscoe and A. Harden. Macmillan, 1896. This is based on the discovery of Dalton's original note-books.

† *Ibid.*

On the Continent, the view prevailed that the homogeneity of the atmosphere was due to the various constituent gases being in mutual solution, much in the same way as water, when it evaporated, was regarded as being dissolved in the air. This probably accounts for Dalton's examination of the solubility of different gases in water. A critical study of his first table, of the relative weights of the ultimate particles of gaseous and other bodies, has revealed that the last two substances, marsh gas or methane, CH_4, and olefiant gas or ethylene, C_2H_4 (giving them their present formulæ), were added between the dates of reading and publication of the paper. It is these two, particularly, that have been taken to imply that Dalton brought forward the theory from a knowledge of the Law of Multiple Proportions, whereas it appears that he just assumed it, as a matter of course, for such substances as consist of the same two elements in different proportions. This he must have done, for the oxides of sulphur, carbon and nitrogen, which the original table included, and he then sought, from such scanty and inaccurate analyses of their composition as existed at the time, evidence to test whether it held good. In a note-book, under date September 6, 1803, are to be found what have always hitherto been stated to be the first known set of symbols for the atoms of the five commonest elements, and, a few pages on, their grouping into various molecules, but this, as will appear, is not quite true.

It is very difficult to acquiesce in giving to Dalton the predominating position now accorded him as founder of the modern Atomic Theory, which, more properly seems to belong to Lavoisier, for his establishment of the conservation of mass in chemical changes, and proof that heat was weightless. Once this was discovered, it is an inescapable necessity that the atoms must combine in simple numerical ratios to form chemical compounds. As pointed out at the time by Sir Humphrey Davy (1778-1829), in realising this Dalton was anticipated by Higgins, in a book appearing in 1789 entitled *A Comparative View of the Phlogistic and Anti-phlogistic Theories*. The author, William Higgins, born in Co. Sligo, Ireland, was the nephew of Bryan Higgins, M.D., of Leyden University, and the better-known physician and chemist, who gave lectures on chemistry in London during the last 20 years of the Eighteenth Century, and spent much time abroad in Russia and in the West Indies advising on problems of chemical technology. William Higgins, who died in 1825, entered Pembroke College, Oxford, but did not matriculate at the University, though he has left in his book a description of the chemical laboratory there then in which he worked. In 1791, he became chemist to the Apothecaries' Society of Ireland and, a little later, librarian and chemist to the Royal Dublin Society, a position elevated to a Professorship by Act of Parliament in 1800. He was elected a Fellow of the Royal Society in 1806, but never presented himself for admission. His 1789 book is primarily an account of the observations and experiments by which he himself, originally a phlogistonist, became converted to the Lavoisierian doctrines. Like Dalton, he held quite irrelevant and misleading views as to the comparative diameters of the calorific atmospheres of the Newtonian atoms. Indeed, he claimed superiority as well as priority over Dalton for having shown how to estimate these diameters, which Dalton did not succeed in doing. In a later book, entitled *Experiments and Observations on the Atomic Theory*, 1814, he claims to have established in the 1789 book all the postulates associated with the Daltonian Atomic Theory.

The Work of William Higgins.

It is to be hoped that future historians of the atomic theory may give more attention to these two books of William Higgins. They certainly serve to establish the writer's view that, once Lavoisier's Theory of Combustion was accepted, the next natural step was the modern atomic theory, and that Higgins definitely took this step 15 years before Dalton. Thus the usually trustworthy historian, Ernst von Meyer, in his *History of Chemistry*, already cited, mentions Davy's original support, in 1809, of the claims of Higgins first to have made use of the atomic theory to explain chemical facts, and then goes on to say—

"Higgins certainly expressed opinions which, on a superficial glance, appeared similar to those of Dalton, stating as he did that the smallest particles combine in simple numerical proportions to form compounds. But these views were brought forward without any internal organic connection, and, moreover, they were not founded on experiment. It became clear to Davy later on that Higgins had no claim to be regarded as the originator of the atomic theory, and he then frankly recognised Dalton's service".

The writer, having recently had the opportunity of studying these two books, has no hesitation in saying that this judgment is completely false. E. von Meyer could never have read or, probably, even seen the books, and the writer doubts whether any of those who supported the claims of Dalton over those of Higgins in the next century were even competent to understand, let alone pronounce so pontifically upon, the reasoning the latter advanced in support of his conclusions, though evidently sufficiently influential to exact this recantation from Sir Humphry Davy. Some account therefore of the actual work of this almost forgotten investigator seems called for to redress, and possibly reverse, the biassed verdict of last century.

A piece of work he did as a student at Oxford is not without some interest and may be first mentioned. The chemical "elaboratory" there, he tells us, was 6 ft. below ground and "the walls of the room afford a fresh crop of nitre every three or four months." This he analysed at Dr. Wall's request and found it to consist of nitrated fixed vegetable alkali (sodium and potassium nitrate) and calcareous nitre (calcium nitrate) in the proportion of about 2 : 1. The interest lies in his having thought at first that it proceeded from minute vegetation, but he found he was mistaken, as it was soluble in water, and concluded that nitre may be formed without the assistance of putrescent matter in a still damp air, "when there is a substance to attract it when half-formed, whereby it is in time brought to perfection," meaning no doubt, as we should put it, when there is a base to combine with the acid. About a century and a half later, another very original Oxford chemist, J. E. Marsh (1860-1938), whose interesting little historical book on the origins of chemistry was cited in Part I, after making a study of the decay of the stone to which the old Oxford buildings are peculiarly prone, came to the very surprising conclusion that it was caused by minute living organisms, or bacteria, in the stone, in presence of ammonia in the air, thus showing that the first surmise of Higgins was not without foundation.

As regards the work with which the 1789 book was primarily concerned, the disproof of the doctrines held by the phlogistonists, this was relatively easy to do since Kirwan's mistaken identification of phlogiston and hydrogen. All the same it would be difficult to devise a neater disproof than one of the many advanced by Higgins. To the phlogistonists, when a metal dissolves in dilute acids the phlogiston, that is, hydrogen, escapes from the metal and the calx (oxide) of the metal left dissolves in the acid. Since, when concentrated sulphuric acid is heated with metals, sulphur dioxide, and not hydrogen, is produced, the salt of the metal formed being the same as with the dilute acid, they had to conclude that the phlogiston escaped with the sulphur dioxide, that is, that the latter contains hydrogen. Higgins therefore argued that if he attacked iron with sulphurous acid, or the solution of sulphur dioxide in water, he ought to get a double quantity of hydrogen, that from the metal being attacked and that from the metal attacked in the preparation of the sulphur dioxide in the first place.

At the time nothing much was known of the action of sulphurous acid on metals, so he tried the experiment and found to his surprise that the iron dissolved without giving off any hydrogen at all, but depositing sulphur, and leaving all the carbon in the iron undissolved. The phlogiston (energy) of the first metal attacked by concentrated sulphuric acid had half-unburned the sulphur in it to sulphurous acid, and the second metal attacked by the sulphurous acid had completed the process and given back the sulphur! Not that Higgins could have been expected to look at it in that light, nor to know that "nascent" (atomic) hydrogen is able to effect with ease spontaneous reductions in the cold which ordinary gaseous (molecular) hydrogen cannot. Nor could he be expected to invoke "passivity" to explain the inertness of certain metals to certain concentrated mineral acids in the cold. But he did show that sulphurous acid was an excellent solvent for iron leaving the whole of the carbon undissolved, unlike the acids that evolve hydrogen and some of the carbon as hydrocarbons, a discovery made some seven years later by the French chemists without, as he complained in his second book, any acknowledgment of his having discovered it before them. It furnished at the time a very elegant method of analysing steel, and though other reagents, as copper sulphate and cupric ammonium chloride, are now preferred for this purpose, the principle is exactly the same—to avoid the loss of carbon with the hydrogen produced by dissolving the iron in other acids than sulphurous acid.

Coming now to his claims to be considered the originator of the modern atomic theory, it is true, of course, as already stated, that in his first book he is more concerned with establishing the doctrines of Lavoisier regarding the nature of combustion and oxidation over those of the phlogistonists, and did not make any claim to originality with regard to his use of the atomic theory to explain chemical phenomena. But that is just the writer's point that there really was nothing very original in doing so, so far as the idea itself, as distinct from the question of priority as to the first person using it, is concerned. It was an inescapable consequence of any chemical reasoning once Lavoisier had established the conservation of weight in chemical changes despite the escape of phlogiston, the fire-material, the calorific fluid—call it what you will—which was not at all so before. It is also quite true that in his second book, as also already indicated, and probably right up to his death, he did not correctly appraise the real basis on which his claim to have founded the modern atomic theory would now be considered to rest. He particularly stresses those parts of it which, as in the case of Dalton, would to-day hardly be considered worth serious critical examination—in his case in his having been the first to assign to the forces of chemical attraction between the atoms constituting compound substances relative numerical strengths in order to account for the many surprising anomalies demanding explanation, which are encountered in the chemical behaviour of matter.

In this, however, the writer, as primarily a chemist rather than a physicist, confesses to a fellow-feeling for him, as he found in the first book exactly the same sort of conundrums posed as those which had puzzled him as a boy a century later. He wanted to know why dilute acids attack metals more readily than concentrated; why combination which does not take place readily between elements sometimes does so spontaneously between the compound of the two and one of them, as with nitric oxide and oxygen; why iron does not rust in dry air, but does in moist, and, again, why it releases hydrogen from water so much more easily than carbon, whereas it is the carbon that takes oxygen from iron oxide when heated, rather than the opposite. From such evidence he made the acute deduction that the attractive forces between bodies are better measured by the difficulty of decomposing them than by their ease of combination. But the simple, yet all-important, idea that the so-called "free" elements are not free, but are compounds of atoms of the same kind, and are from the standpoint of their mutual chemical affinities already compounded as much as, and sometimes more than, those between different kinds of atoms, was still a child of the future awaiting a parent to give it birth.

But though his positive attempts to explain such anomalies were, in those early days of chemical dynamics, doomed to fail, from the point of view of this controversy, they establish up to the hilt his claim to have been the originator of the modern

atomic theory. For example, he gives in both books series of diagrams for the five compounds of nitrogen and oxygen, which are the chemical formulæ of these compounds with one atom of nitrogen combined with from one to five atoms of oxygen. In the first book the first diagram, referring to what is now called nitrous oxide, is omitted, but this may have been a printing error, as he reproduces in the second book five with the text referring to them unchanged. He mentions, however, that though the existence of the first compound had been recognised by 1789, it was not at that time being taken into consideration in his philosophy, and that Davy's minute description of the gas appeared only in a work published in 1800. In the case of sulphuric acid anhydride, SO_3 as it would now be written, he uses the letter S for the sulphur atom, and D and *d* for the two oxygen (dephlogisticated air) atoms, and for the five oxides of nitrogen, P (phlogisticated air) for the nitrogen atom, and *a*, *b*, *c*, *d*, *e*, for the five oxygen atoms, attaching to each bond or link a number representing the force by which the two atoms attract one another. The names, nitrogen and oxygen, of course, only came into use in the next century. Thus, in 1789, Higgins represented the atoms of the elements sulphur, oxygen and nitrogen, by capital letters which denoted the first letters of their names, as in the present system introduced by Berzelius, and it may have been the guilty knowledge of this which made Dalton hostile to the substitution of his own cumbrous special symbols by the simple universal system of Berzelius.

Even so, it is not on these clear enough anticipations of modern chemical formulæ that his real claim to fame rests, but on a truly remarkable combination of just that kind of reasoning and experiment, in which later every boy or girl learning chemistry at school was to be instructed, as to how the molecular composition of gases is arrived at, which it is safe to say could hardly be paralleled in any other work belonging to the Eighteenth Century. He had a considerable knowledge of the experimental facts, which later were to provide the atomic theory with a guess-free basis, concerning the relative volume proportions of gases in their combination and decomposition. He was, of course, well aware that hydrogen and oxygen unite in the volume-ratio of 2 : 1, but, like Dalton in the next century and for exactly the same reason, he assumed that water was a compound of one atom each of its two constituent elements—that is, he gave it the formula HO—because unlike the oxides of carbon, sulphur and nitrogen, there are no "intermediate states of water."

He was aware that sulphur unites with both hydrogen and oxygen to form, respectively, sulphuretted hydrogen and sulphur dioxide, without change of volume and, for the latter, deduced from this many correct conclusions. From the fact that its specific gravity was approximately double that of oxygen, he inferred that the compound contained equal weights of sulphur and oxygen. He also inferred, from the first fact alone, that the "molicule," as he spelt it, of the sulphur dioxide "must be surrounded with as large atmospheres of fire as those of oxygen, or at least that they are as far asunder." This is a clear enough anticipation, for the case of these two gases, of Avogadro's Law for all of them. The reader will note that exactly the same applies to hydrogen and sulphuretted hydrogen, though, curiously, Higgins did not specifically refer to this or grasp its importance. But there is something even more curious. From the same fact, that the volume of oxygen is unchanged when made into sulphur dioxide, Higgins assumed that, as in the case of hydrogen and oxygen, one atom of each of the elements combined, so that he got for the formula of sulphur dioxide SO, just as he assumed that of water to be HO, which with the (wrong) analytical datum that the weight of sulphur in sulphuric acid is twice the weight of oxygen, exclusive of water, led him to deduce for sulphuric acid anhydride the formula SO_2 already cited. Again, the reader will note, as regards the sulphur dioxide, that the reason for giving it the formula SO applies equally to sulphuretted hydrogen, which therefore can just as reasonably be written HS. But Higgins, instead, proved rigorously, in perfectly modern fashion, that if water is HO and sulphur dioxide is SO, sulphuretted hydrogen is HS_2! That he was right can be seen merely by comparing the present formula for water, H_2O, and sulphur dioxide, SO_2, with those assumed by Higgins, because, in terms of the atomic weight of oxygen as 16, the present formulæ make those of hydrogen and sulphur 1 and 32, but the formulæ used by Higgins make them 2 and 16; so that to modernise the formulæ used by Higgins the number of atoms of hydrogen in the molecule must be doubled and the number of sulphur atoms halved, changing HS_2 to SH_2. It should perhaps be mentioned that in his first book he got the ratio of S to H atoms 9 to 5, which, later, more exact experiments corrected to 2 : 1. Higgins stuck to this formula, HS_2, in his later book and twitted Dalton with having got the ratio at first SH_2 and then altering it to SH, "thus falling from one error into another."

All three were, of course, wrong. Dalton with his two shots straddled the target, but Higgins was the farther out and got the ratio transposed. All the same, the writer has yet to find in any of Dalton's work on the subject anything a tithe as interesting as the reasoning by which Higgins deduced his perfectly correct result on his initial incorrect premises as to the formulæ of water and sulphur dioxide. He exploded a mixture of equal volumes of sulphuretted hydrogen and oxygen, which caused a copious precipitation of sulphur, which he correctly estimated as one-half the total sulphur in the sulphuretted hydrogen. He found that the volume was reduced thereby to one-fourth, consisting of practically pure sulphur dioxide, as he proved both by absorbing it with barium nitrate solution, which produced no precipitate of barium sulphate, and by treating it with an equal volume of sulphuretted hydrogen, which reduced its volume to one-half, with precipitation of sulphur. He knew, since the sulphuretted hydrogen contains its own volume of hydrogen, that one-half of the oxygen had been used in oxidising the hydrogen to water, and, since sulphur dioxide contains its own volume of oxygen, that the other half had gone to produce the sulphur dioxide formed. Taking the volume of hydrogen in the sulphuretted hydrogen as representative of one atom of hydrogen, the half-volume of oxygen it combines with is (on his formula for water) representative of one atom, as is the half-volume used in oxidising half the sulphur which contains, combined to this one atom of oxygen (on his formula for sulphur dioxide), one atom of sulphur. As only half the sulphur is oxidised and the other half is precipitated as element, the volume of sulphuretted hydrogen taken as representing one atom of hydrogen therefore contains two atoms of sulphur. The argument involves no assumption at all, not even Avogadro's.

The weakest point in the reasoning, or at least of his description of it, is in his estimate that one-half of the sulphur is precipitated. This is quite correct, but how far it was a deduction from known data regarding the specific gravity of sulphuretted hydrogen and how far a mere guess from the quantity of sulphur thrown down, or whether he did other experiments varying the proportion of oxygen to arrive at the correct result, it is impossible to tell from his own description, which is on this point obscure and inadequate. It will be generally admitted, however, that it was a noble first effort to throw light on the molecular constitution of gases in general and in particular of that of sulphuretted hydrogen. That during the rest of his life he does not seem to have pursued the subject further may possibly have been due to just the feature already mentioned, that until Dalton got such credit for "originating" the modern atomic theory, he did not consider there was anything particularly remarkable in using the atomic theory to account for chemical changes. He was a chemist with original physical ideas, whereas Dalton was a physicist without them, and the attitude of chemists towards his work at the beginning of last century was much the same then as they displayed in the beginning of the present century to the theories of atomic disintegration and the conception of isotopes.

It is conceded in the biography of Higgins in the *Dictionary of National Biography*, that he was the first clearly to have enunciated, in his 1789 book, the Law of Multiple Proportions, but his biographer goes on to state that in his 1814 book he "made an unworthy attack on Dalton." Rather let Higgins speak for himself, for his closing works still sound eloquent across the years, ostensibly as the wronged calling for justice, but even more timelessly as the disillusionment of age correcting the early chivalry of youth.

"The generous age of chemical science is no more. In my early days it was my fortune . . . to associate with many of the venerable fathers of our present system. In that auspicious period the ultimate and ardently expected object of research was truth, not the advancement of an individual's reputation. Philosophers were then eager to attribute the merit of discovery to its rightful owner, not to appropriate it to themselves or others. But now, in the vale of life, I am myself obliged to rescue the labours of my youth from the claims of those who have adopted them without ceremony, and who have even attempted to force them from me by means of their combined exertions . . ."

Of all the steps necessary to establish the Atomic Theory, as well as the twin Molecular Theory, Dalton's contribution now seems to have been the least. In recognising the theoretical necessity of the Law of Multiple Proportions and seeking evidence of it by chemical analysis, he was anticipated by Higgins. His sole claim to be the founder of the modern atomic theory rests on his "New System" attracting general attention among his contemporaries as showing how, when the weights of the atoms were taken into account, as well as their chemical nature, it became possible to substitute for the vague speculations concerning atoms hitherto prevailing, definite conceptions, which could be put to experimental test, thus raising the possibility that in time it should become possible to assign to the various elements definite relative atomic weights. In this, as it happened, it was not vital that the atomic weights so found were not the real atomic weights, but average atomic weights, since these averages are themselves natural constants. Long before the conception of isotopes arose, special experiments had shown that the atomic weight of the element is the same from whatever natural source it is obtained, or, as we put it now, the isotopic constitution of the elements in Nature is invariant.

As Dalton's contemporaries recognised, his so-called Atomic Weights were merely arbitrarily disguised chemical combining ratios or equivalents. His "law of greatest simplicity" was nothing but a relic of the pretentious logic of the schoolmen which Francis Bacon, two centuries before, had scorified in his *Novum Organum*, elevating a postulate into a principle. Thus water was to him, HO, and ammonia, NH, because these were the simplest formulæ, which were wrong, and the two oxides of carbon were CO and CO_2, which were right. His own writings on the subject are so irrelevant as to be almost unreadable to-day. They were primarily concerned with the molecular, rather than the atomic theory as now understood, and, moreover, with the purely speculative and totally false theory of the static internal constitution of gases which he was trying to establish.

It is very interesting to find, from an entry in one of his note-books dated some six weeks before his first oral communication of the theory in 1803, that, from the very start, he came up against the difficulty that he never surmounted, and which is still the *pons asinorum* to the beginner to-day. Dalton saw that, though the relative densities (weights per unit volume) of different gases are probably in some way related to the relative weights of their ultimate particles, they could not be the same thing, because steam is lighter than oxygen, but the ultimate particle of steam, containing hydrogen as well as oxygen, must weigh more than the ultimate particle of oxygen. This led him to the conclusion that the "confused idea," as he later termed it, that the same volumes of different gases contained the same number of ultimate particles, cannot be maintained, and this he held till his death in 1844. He took the view that the numbers must be different in order to account for the homogeneity of the atmosphere.

On the other hand, in the Law of Partial Pressures, known by his name, which stated, in effect, that a

constituent of a mixed gas is dissolved by liquids as though it alone occupied the whole space to the exclusion of the others, Dalton may be considered to have contributed not only experimentally to the establishment of the modern view, that the molecules of gases are in continuous, free and independent motion, but also an interesting new and pregnant idea.

The succeeding steps in the progress of the molecular and atomic theories through the Nineteenth Century need only be briefly reviewed. What is really remarkable, looking backwards, is the superlative practical importance, as the sequel has proved, of being able definitely to determine such matters as to whether, for example, water is HO or H_2O. A century ago, even to most chemists, such questions appeared only academic, and one cannot imagine any philosopher trying to read the riddle of the material universe even guessing that in the solution of this problem lay the key, and that until it had been found no real progress could be looked for in this the most profound, as it is the most ancient of all scientific inquiries.

(To be continued.)

LITERATURE.

Manual of Photogrammetry. Edited by P. G. McCurdy, L. A. Woodward, and others, for the American Society of Photogrammetry. Pitman Publishing Corporation, 2, West 45th-street, New York 19, U.S.A. [Price 8·50 dols.]; and Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 45*s.* net.]

Wherever new maps are wanted quickly and cheaply, the photogrammetrists now claim to be able to supply them. The science of obtaining reliable measurements by means of photography, almost unheard of 15 years ago, has lately made remarkable advances in step with aviation and photography, some highly ingenious instruments and techniques having been developed for the purpose of translating detail from photograph to map sheet. Whether or not these methods are soon to replace all but the most fundamental geodetic surveys may be debatable, but there can be no dispute about the value of the almost unlimited matter that can be produced rapidly, and reproduced even more rapidly, and cheaply by an aerial survey. To engineers interested in the construction of highways, in town planning, in water power and the navigability of waterways, or in the transmission of electric power lines through new territory; to foresters and agriculturalists concerned with soil types or crop possibilities; to geologists wishing to study structures for potential mineral deposits—to list only a few likely users—the products of an aerial survey enhanced by colour photography and stereoscopy are rich in information.

The multifarious uses to which Military Intelligence can put aerial photographs are well known to be chiefly accountable for the progress made by this science as soon as the needs of global war caused national treasuries to open freely. Vast Continental areas still remain to be surveyed and mapped on a scale greater than 1 : 250,000; but, many things being considered, it is not surprising that the prohibitions of national security continue to impede publication of a completely up-to-the-minute account of all that is known of photogrammetric techniques. The American Society of Photogrammetry are to be congratulated on their prudence as well as their enterprise in offering, at this stage, only a preliminary edition of their *Manual*, while promising that a revised and fully supplemented edition will follow "as soon as time permits." Already the book has some half million words on nearly 4 lb. of paper. By the time a full chapter on Field Inspection and Completion has been added and supplementary information has been released by Government departments—for instance, in the matter of the developer, which is known to be capable of reducing graininess in photographs, or concerning Sonne continuous-strip photography, to mention but two points—some careful pruning will have to be done if the first edition is not to run into two volumes. There is little redundancy in the present edition, although one of the later chapters, dealing with training and education, might have been left to the technical institutions concerned to bring to the notice of the students to whom this book is particularly directed.

Mr. P. G. McCurdy and his four eminent co-editors have effectively avoided overlapping in their orderly compilation of the contributions of some 40 specialists into chapters containing from one to six papers each; but it is remarkable that the list of chapter headings is nowhere supplemented by a complete list of sub-headings detailing the contributions, together with the names and qualifications of their writers. A most valuable feature of this manual is its final chapter, in which the Committee of Nomenclature of the Society have defined plainly a large number of the terms peculiar to photogrammetry, using particularly lucid diagrams for the purpose. So often a young science becomes overburdened with loose alternative terminology which can be an unparalleled nuisance to students. This chapter would not be misplaced at the beginning of the text; or do readers of text-books, like many readers of novels, read the last few pages first? In this book, it is more likely that a splendidly illustrated chapter on photo-interpretation would claim first attention, although the whole book abounds in commendable illustration. The mathematician will be attracted by a lengthy contribution by Earl Church, Professor of Photogrammetry at Syracuse University, in which are lucidly analysed the four basic problems involved in the exact computation of survey data from measurements made on aerial photographs, before a relatively simple but essentially practical method of calculating areas, distances and horizontal positions of ground points, which may be used to facilitate the extension of surveys without ground control, is offered as an alternative to the longer calculations proper to the orthodox four-point treatment.

The descriptions of the many basically optical instruments now used in mapping from aerial photographs will be welcomed by the general reader who has no access to the actual apparatus, which is always expensive, and, in some cases, rare. The Bausch and Lomb Multiplex equipment, the Fairchild stereocomparagraph, the contour finder and several types of "Sketchmaster" made by Abrams, and the unique Brock stereometer are among the numerous instruments which, with their associated equipments and techniques, are described. Photogrammetric optics is discussed only to an extent limited by the available space; but it has been treated clearly as well as succinctly, and, as is the case with other contributions, a bibliography separate from the reading list given at the end of the *Manual* is appended. It seems highly probable that this book will achieve its aim to become the standard work on photogrammetry, but it is rather remarkable that so little attention has been paid to the aviational aspects of the subject; the great potentialities of the helicopter, the gyroscope and the radar altimeter certainly deserve more extended notice.

Dynamic Motion and Time Study. By James J. Gillespie. Paul Elek (Publishers), Limited, 36-38, Hatton-garden, London, E.C.1. [Price 7*s.* 6*d.* net.]

Mr. Gillespie's books on works management problems are distinguished by a forthright commonsense that does not spare the pretentious pseudo-science with which so many writers attempt to clothe their systems. In this little book, he concentrates his attack on some modern methods of time and motion study; and a powerful attack it is, though some readers may think that, in his efforts to pulverise the theories of what he calls the Gilbrethian micromotionists, he occupies an excessive proportion of his limited space in philosophic generalisations which are sometimes more entertaining than relevant. The enemy may be scattered in confusion, but the plain engineer, after following the author from Plato to Burns, will be inclined to ask what the experts are quarrelling about.

The answer can be given quite briefly. One school of motion study proceeds by analysing the motions of human limbs (and even minds) into minute discrete acts, such as grasping the fingers, and builds up standard times by a synthetic process involving the addition of numerous fractional times. Mr. Gillespie says, in effect, that this is all nonsense; that a composite action will proceed by a rhythm natural to the type of person performing it and influenced by his environment; and that the summation of small durations not only involves a cumulative error, which the protagonists of the method cover by large and uncertain fatigue allowances, but may fail completely to correspond with the manner in which the composite movement is actually made. On the whole, we think that, in large measure, Mr. Gillespie is right. When he contends that a wrist watch may be quite sufficient for practical time studies, and that fractions of a second are a sure sign of heresy, he will strike a responsive note in the minds of most engineers; though it is to be hoped that he will not thereby encourage the type of time study in which a manager, casually pausing at some machine, will time one cycle on his wrist watch and subsequently proclaim the result as an average time for the operation.

In the few pages devoted to the actual details of his own methods, Mr. Gillespie proposes an alternative system of symbols to the "therblig" for motion studies, which he calls "dynamic symbolism." These may be less adaptable to quantitative evaluation, but are certainly much more representative of the actions they stand for; indeed, the author is to be praised for his skill in selecting just the right number of simple yet expressive symbols, which are delightful in the neat and sometimes amusing way that they describe the various actions. As indicated, no motion-element times are associated with these symbols, since the author contends that such times are valueless and that motion, not time of motion, is being studied. The only timing that he considers to be of unqualified value is the average production rate for the operation, and this method of analysing motion by symbols is for the purpose of finding out, in conjunction with all other relevant information regarding the character and environment of a particular operator, why his output deviates from this time, one way or the other. There is a chapter by Mr. C. H. J. Cooper on the practical application of this system of motion study, and stress is laid on the study of operator reaction.

Engineering Problems Manual. By Professors Forest C. Dana and L. R. Hillyard. Fourth edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 3.25 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 16*s.* 6*d.*]

A difficulty that teachers of engineering frequently encounter is that relatively few of their students have received sufficent preliminary training to make the best use of the instruction given. The failure of many students to obtain satisfactory results in their examination can, in fact, be attributed not so much to mental inability as to unsystematic methods of reasoning, arithmetical inaccuracy, and, in many cases, lack of common sense. This revised edition of the *Engineering Problems Manual* has been written for the purpose of dealing with this particular aspect of a student's education; therefore, the subject-matter is not so much concerned with the acquirement of specific factual knowledge as with the training that is necessary to make him think logically, to attack problems in a systematic manner, to be accurate in arithmetical work, and to take a pride in craftsmanship and general habits of neatness. Essential rules are laid down for inculcating habits of accuracy and neatness, and the subsequent chapters deal with the use of logarithms, the slide rule, precision in arithmetical work, curve-drawing to fit experimental data, and graphical and geometrical applications of the calculus. Nearly 400 problems are given, covering a wide range of comparatively simple topics, the data in some of these being purposely omitted so that any desired numerical values can be introduced. The student who has gone through a course of instruction in which the methods advocated in this book are rigidly enforced will probably show a better appreciation of the value of his technical training than the workman of whom the authors relate that, when reproved for a blunder and told to use common sense, he replied; "But, sir, common sense is a rare gift of God and I have only had a technical education."

AN ELECTRICAL SLIP-RECORDER.

BY N. HAGLOV, A.I.E.E., and R. C. PARKER, Ph.D., A.R.C.S.

WHEN an investigation on flat and V-belt drives was being carried out by the Research Division of Messrs. Ferodo, Limited, information was sought on the variation of slip—that is, the difference in speed between driving and driven shafts—over a period of several weeks. A simple solution would have been herewith. Direct-current generators A and B are attached to the driving and driven shafts, respectively, and are connected so that at any instant the current passing through a circular coil 2 is substantially proportional to the voltage of the generator coupled to A, and the current through a second circular coil 1 is proportional to the difference between the voltages of generators A and B. If E_A and E_B represent the voltage of the two generators, and i_2 and i_1 represent the instantaneous values of the current through coils 2 and 1, respectively, we have that

$$i_2 \propto E_A \propto N_A. \quad . \quad . \quad (1)$$

and

$$i_1 \propto E_A - E_B \propto N_A - N_B \quad . \quad . \quad (2)$$

Fig.1.

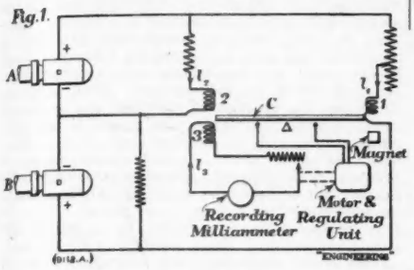
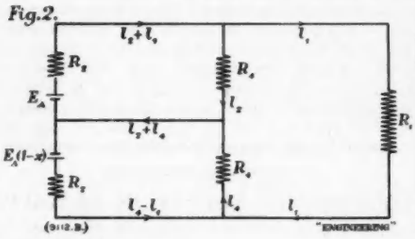


Fig.2.



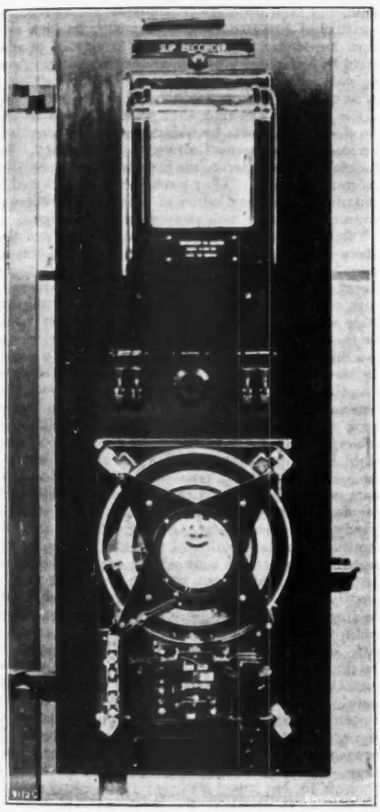


FIG. 3.

Fig.4.

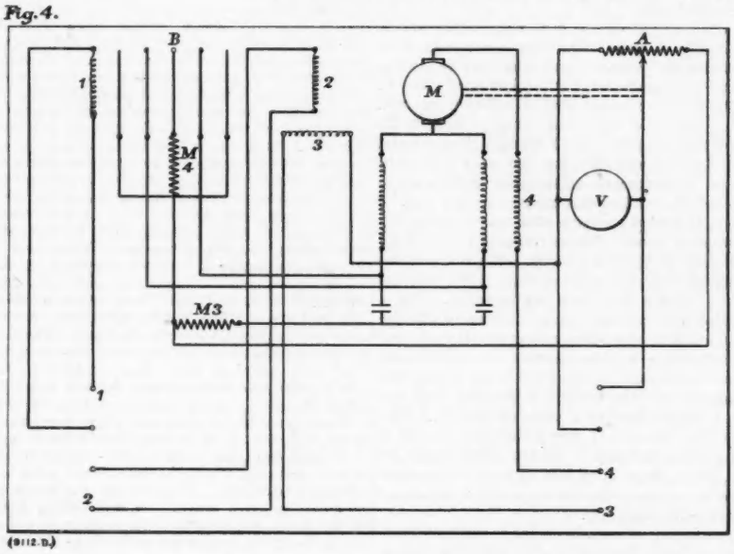


Fig.5.

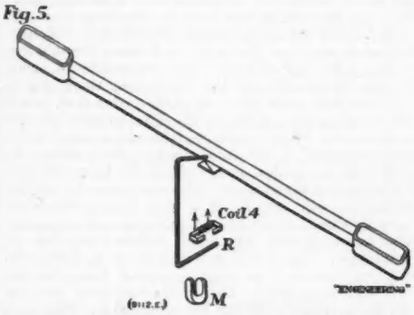
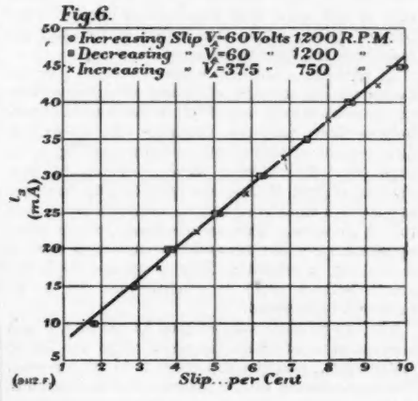


Fig.6.



or, from (1) and (2),

$$i_2 \propto \frac{i_1}{i_2} \propto \frac{N_A - N_B}{N_A}. \quad . \quad . \quad (3)$$

If, therefore, coil 3 is connected to a separate supply, and i_3 is varied so that the beam is maintained in its equilibrium position, a recording milliammeter placed in the circuit may be calibrated in terms of the percentage slip. Automatic operation was achieved along these lines by means of a motor-driven potentiometer, operated through contacts which opened and closed through small deflections of the beam.

The circuit conditions which are required for equations (1) and (2) to be valid follow from the following considerations of the circuit diagram, Fig. 2. In this diagram, R_2 represents the resistance of the tachometers, and $E_A(1-x)$ the instantaneous voltage of tachometer B, where x denotes the fractional slip $\frac{N_A - N_B}{N_A}$. The three circuit equations are as follows.

$$E_A = i_1(R_2 + R_3) + i_1 R_2;$$

$$E_A(1-x) = i_2(R_4 + R_3) - i_1 R_2;$$

$$E_A x = i_1(2R_2 + R_1) + i_2 R_2 - i_2 R_2;$$

which gives the following equations for i_1 and i_2,

namely,

$$i_1 = E_A R_4 \frac{x}{2R_2 R_4} + R_1 R_2 + R_1 R_4$$

$$= ax \text{ where } a \text{ is a constant} \quad . \quad . \quad (4)$$

and

$$i_2 = \frac{E_A}{R_4 + R_2}\left[1 - \frac{x}{2 + \frac{R_2}{R_4} + \frac{R_1}{R_2}}\right]$$

$$= b(1 - cx) \text{ where } b \text{ and } c \text{ are constants.}$$

Provided that $cx < 1$, this gives

$$i_2 = b \quad . \quad . \quad . \quad . \quad (5)$$

the use of two direct-current generators, the appropriate voltage ratio being recorded by means of a standard automatic potentiometric recorder. This method had to be rejected owing to the fact that a continuous record was sought, whereas the available recorders only operated on a one-minute time cycle. An alternative method was therefore devised by Messrs. Asea Electric, Limited, Walthamstow, which incorporated an existing instrument capable of continuous operation. The method (British Patent No. 570,725) was independent of sudden changes in line voltages and was fully automatic. Since the completion of the instrument, the authors have found so many other applications in industry for an apparatus of this type that a note on its construction was thought to be of value.

The method is shown diagrammatically in Fig. 1, where N_A and N_B represent the speed of the shafts A and B, respectively. The speed-voltage characteristics of the two generators must, of course, be linear and identical.

Coil 1, which lies in the field of a permanent magnet, is attached to one end of a rocker arm C, so that, by virtue of the current through the coil, a turning force is exerted on the arm, proportional to i_1. Coil 2, attached to the other end of the rocker arm, lies in the magnetic field of the coaxially mounted excitation coil 3. Thus the force exerted, on the end is proportional to the product $i_2 i_3$, where i_3 is the current flowing through coil 3. When the beam is in equilibrium under the two opposing forces we have that

$$i_2 i_3 \propto i_1$$

so that, from (4),

$$i_3 \propto \frac{i_3}{i_2} \propto x. \quad . \quad . \quad . \quad . \quad (6)$$

It follows that equation (5), and hence equation (6), only holds for values of cx small to unity. In the arrangement eventually chosen, $R_2 = 100$ ohms, $R_4 = 2{,}500$ ohms, and $R_1 = 185$ ohms, giving values of cx of 0·025 and 0·005 over the required slip range.

The instrument to which the direct-current generators are connected was manufactured by Messrs. Asea Electric, Limited, and is shown in Fig. 3, page 365. The lower half of the instrument shows the modified Asea transmitter which contains the motor-driven potentiometer, the balance relay consisting of the rocker arm and coils 1, 2, and 3, and the anti-hunting device. Coil 1 is shown on the left-hand side and coils 2 and 3 on the right. The upper part of the illustration shows the recording milliammeter, one of the standard types manufactured by Messrs. Nalder Brothers and Thompson, Limited. The chart is calibrated directly in percentage slip and has a paper speed of 3 in. per hour. The generators were standard G.P. transmitter units manufactured by the Record Electrical Company, giving 0·05 volt per r.p.m. and having an armature resistance of 80 ohms. The transmitters were supplied as a carefully matched pair.

The arrangement of the Asea transmitter unit is shown in Fig. 4, page 365. The instrument comprises a toroidally-wound potentiometer resistance A driven by a small motor and a balanced relay B. The potentiometer is fed with a constant current, through a barretter regulating lamp. Currents I_1, I_2, I_3 flow through relay coils 1, 2 and 3, respectively. Current I_1 varies with slip, and the relay is brought to balance by automatic adjustment of the excitation current I_3. When the balance of the relay is disturbed, the relay contacts close and start up the potentiometer motor. These contacts are actually a double pair, an inner and outer. When the variation is small, only the inner contact closes and the motor starts with resistance M4 in series. For a large variation, the outer contact closes also and the motor starts with the series resistance shorted out, thus accelerating the restoration of equilibrium. The motor is arranged so that it always rotates the potentiometer tapping in such a direction that the relay is brought back to a state of balance. The result is that the direct current applied to coil 3 from the potentiometer is always proportional to the slip, and a fraction of this current is therefore fed to the recording milliammeter, which is calibrated directly in percentage slip.

The double pair of contacts helps to prevent overshooting on large changes of slip, since the motor runs at full speed until approaching closely to the balance point, when the motor is fed through resistance M4, halving its speed.

In addition, a recalling magnet, energised by the motor current through coil 4 and providing a force on the relay arm in opposition to the normal out-of-balance force, prevents hunting. The mechanical arrangement of this system is shown in Fig. 5, on page 365. A centering force, provided by permanent magnet M, and the anti-hunting force are applied to a small steel rod R, connected by an arm to the balance. This means that, as the relay approaches equilibrium and the correcting force is decreasing, a retarding force is applied until the actual balance point is reached and the motor current is interrupted.

The slip recorder was designed for use on a V-belt test machine for which the speed range was 750 to 1,500 r.p.m., and the slip range 2 to 10 per cent. The performance of the instrument was therefore checked over the above range, and a scale graduated in percentage slip was affixed to the recording milliammeter. Calibration was effected by replacing the direct-current generators by two low-tension batteries. Corresponding to any one particular speed, the voltage V_A was kept constant, and the voltage V_B was varied over the required slip range by means of a voltage divider. Variable resistances were connected in series with both supplies, and were adjusted until the overall resistance matched the internal resistance of the generators. To obtain a correct setting of the variable resistances for each setting of the voltage divider, it was necessary to replace the batteries with resistances equal to the appropriate values of the internal resistance of the batteries.

Fig. 6, page 365, shows the calibration chart taken over a slip range of 2 to 10 per cent. for values of V_A corresponding to 750 and 1,200 r.p.m. of the driving shaft. The relation between the current i_3 and the quantity $\left(\frac{V_A - V_B}{V_A}\right) 100$ is sensibly linear. The maximum departure of any one reading from the straight line occurs at a slip value of 10 per cent. and corresponds to an error of 0·2 per cent. slip. No greater error was detected on calibration charts taken for different values of V_A. Within the accuracy of the instrument, there is no detectable hysteresis. The voltage change in $(E_A - E_B)$ required to operate the potentiometer was 0·05 volt, which corresponds to a change of 0·07 per cent. slip at 1,500 r.p.m. and 0·14 per cent. slip at 750 r.p.m. Although the calibration was restricted to values within the above range, it is clear that the use of the instrument can be extended by suitably modifying the circuit constants.

ELECTRICITY SUPPLY IN KUWAIT.

The inhabitants of the independent Arab state of Kuwait number about 90,000, nearly all of whom live in or around the town of that name. This stretches about three miles along the Persian Gulf and extends inland for about one and a half miles. It is surrounded by a 14-ft. wall and comprises a prosperous mercantile community with the largest Arab shipbuilding industry in the Gulf. For many years the only source of electricity in Kuwait has been a 174-kW, 220-volt Crompton dynamo. This was driven by a Ruston-Hornsby oil engine and was used solely to supply the Sheik's palace and government buildings. As a result of a survey made early last year, however, it was decided to provide a supply throughout the town, and a scheme was therefore prepared, which included three 175-kW, 380-volt, three-phase 50-cycle alternators. These sets are to be used to supply a four-wire network in the area of the power station direct, as well as a 200-kVA, 380/2,200-volt transformer from which a connection will be made to three 50-kVA substations in the more remote areas. A contract for the whole of the necessary equipment has been placed with Messrs. Crompton Parkinson, Limited, Astor House, Aldwych, London, W.C.2, the sets being driven by two new Ruston-Hornsby Diesel engines and the existing oil engine.

Apart from the engines and alternators, the power house will contain three automatic voltage regulators a five-unit main switchboard, a low-voltage distribution board, and the 200-kVA transformer with a high-voltage switch-fuse. The voltage regulators will be mounted in three separate cubicles which form part of the main switchboard. The switchgear will consist of an oil circuit breaker for each of the alternators, as well as one for the 380-volt side of the transformer, and a fifth for controlling the local three-phase four-wire supply. The 200-kVA step-up transformer will have delta-star windings, the star point being brought out on the 2,200-volt side for solid connection to earth. On the output side of this transformer there will be a 100-ampere triple-pole rotary oil switch-fuse, which will be mounted on the tank. The transformer will be connected by a 0·04 sq. in. three-core cable to the first substation, 1,000 yards distant, from which two 0·0225 sq. in. cables, each 1,500 yards long, will feed the other two substations. The equipment in the first substation will consist of a four-unit switchboard carrying three oil-immersed triple-pole non-automatic 300-ampere on-load ring-main isolators and an oil switch-fuse. There will also be a 50-kVA, 2,200/380-volt transformer from which the local four-wire network will be supplied. One of the ring-main isolators will be in circuit with the incoming cable, while each of the other two will be connected to one of the outgoing feeders. The transformer will be isolated on the high-voltage side by lowering the switch-fuse. Each of the other two substations will be equipped with a similar 50-kVA transformer, switchgear and low-voltage distribution board. All the cables will be laid direct, with the usual protection against mechanical damage, and, as the soil contains gypsum, they will also be protected against corrosion.

Works Education Scheme.—A scheme for the vocational and general education and training of both young and adult employees is to be introduced by Vauxhall Motors, Limited, Luton. It is intended that the scheme shall cover the education of young people up to the age of eighteen and the provision of facilities for the further training of adults; if found desirable, evening courses will be arranged at a later date.

RECENT DEVELOPMENTS IN WELDING.

The autumn meeting of the Institute of Welding was held at Olympia, London, W.14, on Thursday and Friday, September 11 and 12, four papers being presented at two sessions.

The first of these papers was that read by Mr. H. E. Lardge on "Welding in the Development of Jet Propulsion Engines." On these engines, the author said, the welding engineer was primarily concerned with the combustion and exhaust systems which were made almost entirely of sheet metal. These systems had to operate at high temperatures, which gave rise to considerable thermal stress. Alternating stresses, which were caused by pulsations of varying frequencies and magnitude in the air stream, were also present. Moreover, the need for plant interchangeability made it imperative that close manufacturing tolerances should be observed. All these factors influenced the choice and operation of the processes used. From a welding standpoint the question of materials was important. Inconel was first used for the parts exposed to the highest temperatures, such as the flame tube, but finally a nickel-chromium alloy in sheet form, known as Nimonic 75, was adopted. For components such as the exhaust unit and jet pipe, austenitic stainless steel of the weld decay-free variety was employed, while mild steel protected from corrosion by spraying with aluminium had been found satisfactory for the outer casings of the combustion chambers where there was no direct contact with the hot gases. The high yield point and high ultimate tensile strength at room temperature of Nimonic 75, together with its high rate of work hardening, added to the difficulty of producing parts by spinning, pressing or deep drawing. Annealing naturally produced surface oxide film, which had to be removed before welding. The mechanical design of the engines was such that solid flanges attached to the sheet-metal parts by welding had to be provided for purposes of mechanical strength and rigidity. These flanges, being exposed to the hot gases, had to be of heat-resistant material. They were therefore machined from centrifugally-cast cylinders of austenitic stainless steel containing a fairly high percentage of tungsten.

For fabricating purposes, the carbon arc was chosen where fusion welding had to be used on the main assemblies as the heat was localised and distortion was therefore likely to be a minimum. The nature of the work was also such that a short easily controlled electrode was required and this requirement was fulfilled by the carbon arc. Oxy-acetylene welding was used to a limited extent, although distortion was a problem, but the metallic-arc process was not considered suitable for the relatively thin gauges employed. Some experimental work had been done with the hydrogen torch and flash butt welding had many attractions, although some development work was needed before it could be adopted generally for this class of work. Of the resistance welding processes, spot, stitch and roller seam welding were found to be the most suitable. The last had been most exploited, as it was consistent, speedy and convenient. Stitch welding lent itself admirably to the welding of irregular shapes, or interrupted straight weld runs where seam welding could not be employed. Spot welding was used most frequently for tacking purposes prior to stitch or seam welding, though there were many instances where it could take structural loads alone or in association with silver-alloy brazing. Silver-alloy brazing with the oxy-coal-gas torch for mild-steel and stainless-steel parts was used to a considerable extent. Another useful process for assembling mild-steel parts was copper brazing carried out in a large continuous conveyor furnace with controlled atmosphere. This furnace was installed primarily for the "clean" interstage annealing of pressings in stainless steel and Nimonic 75, but it had also proved successful in annealing welding sheet-metal structures in the heat-resistant alloys.

Mr. Lardge's paper was followed by a communication on "Some Novel Developments in Design and Operation of A.C. Arc Welding Plant," by Mr. E. C. Davies. Dealing first with the transformer type of plant for manual welding, the author said that its popularity was due to the availability of suitable electrodes, low first installation and running costs, and absence of arc blow. Compared with direct-current plant, however, it had a number of disadvantages, among them being low inherent power factor, unbalancing effect on the three-phase supply systems, increased danger from shock, and unsuitability for certain non-ferrous work. The power factor could be improved by connecting a static condenser across the primary terminals of the transformer. The cost of this still made the total expenditure less than for an equivalent direct-current set. Unbalance difficulties mainly arose where the welding load was an appreciable percentage of the total demand and could be overcome by connecting a single-phase set across two phases or an approximately equal number of sets on each phase. One method of eliminating the

risk of shock was to reduce the voltage of the transformer to a low value whenever welding was discontinued. This could be achieved by connecting a reactance in series with the primary winding, or more simply by incorporating a switch in the electrode handle, so that the operator could isolate all exposed metal portions from the welding supply at will.

The problem of making alternating-current welding applicable to non-ferrous work resolved itself into ensuring that re-ignition took place regularly with the minimum delay. The factors controlling re-ignition were partly electrical and partly thermal. At each instant of zero current, the welding plant must provide the minimum voltage necessary to re-strike the arc, the actual value being determined by the compositions of the electrode, flux coating and work piece, and by their momentary temperatures. The flux coatings available for use with aluminium and copper alloys had not such good ionising properties as those used for ferrous work, and the blanketing effect was not sufficient to prevent the excessive variations in temperature which occurred at 50 cycles owing to the high thermal conductivity of these metals. Some progress had been made towards the solution of these problems by applying the so-called pilot-arc principle, in which a separate high-frequency source of supply was connected between the main source of supply and the work so as to increase the arc gap ionisation. Arc blow could be anticipated by using a frequency of 500 cycles per second, which was equivalent to the direct-current arc. Rotating plant, however, was necessary to supply this, and the problem was to provide an alternating-current generator which would be competitive in performance and cost with a direct-current machine of similar output.

The troublesome effect of transformer welding plant on the loading of the supply system could be mitigated by using twin electrodes, which were supplied from a three-phase to two-phase transformer, the work being connected to the neutral of the two-phase winding. During welding, the effective resistance between each electrode tip and the workpiece was then considerably less than that between the two electrode tips. In consequence, practically all the current passed between the workpiece and each electrode in turn, and the demand on the three-phase system was balanced. Arc stability and thermal efficiency were greatly improved, since the two arcs burnt alternately and one was always maintained during the reversal period of the other. It had been found that, with equal power input, the rate of deposition from the two-phase arc was about 30 per cent. faster than on single phase, and the line current was 60 per cent. of that taken by the single-phase welder.

At the meeting on Friday afternoon, September 12, the first paper read was by Mr. A. H. Burt on "The Development and Application of Stud Welding." This gave details of the plant, described in ENGINEERING on page 375 of vol. 163 (1947), for arc-welding studs to plates or structures, using a pistol-grip tool for the control of the stud. An interesting point was that the heat was very localised and the distortion of even thin plates was therefore practically negligible. Stud welding could be carried out in the vertical, horizontal or overhead positions, but as in other forms of arc welding, it was preferably carried out in the down-hand position. Where the larger studs were welded horizontally, it was necessary to use a refractory ferrule, so that a complete collar of molten metal was formed round the base of the stud. Stud welding could be used, in place of riveting, for welding plates to tubular sections, and for locating lagging material on boilers. It was now employed extensively in shipyards for locating wooden plants on the steel decks.

The final paper, on "Some Aspects of Welding Repairs," was presented by Mr. J. K. Johannesen. The ultimate progression towards monobloc construction by way of prefabrication methods, the author said, had influenced both to the extent that there was little demarcation between large-scale repair and large-scale fabrication, as instanced in the fabricated forebody incorporated in an all-welded Liberty ship and the prefabricated forebody joined by welding to a damaged tanker. Yet the latter was definitely a repairs contract. Large-scale procedures in both were normally based on centre-point commencement with radial progression, whereas smaller repairs were largely influenced by the degree of surrounding restraint after incorporation, a characteristic which became common to both when the unit-fabricated structure was set into the assembly. A further difference was the preponderance of positional work, thus limiting the gauge of the electrode and placing more responsibility on the human element, as compared with the flat welding secured under optimum conditions by manipulators and the heavy core sizes, which were such a feature of fabrication work.

A typical example of boiler repairs, utilising mainly butt welding, was the replacement of fourteen faulty areas of tube plating where rivet fracture was pronounced, by cutting a section out of each and replacing with a butt-welded patch. The first tube-plate saddle was veed from the fire side only and butt-welded. After completion, however, it was found that the right-hand lower horn had sustained a distortional pull inwards. By shallow gouging on the water side of the butt an equalising stress was imposed, which drew back the plate into correct vertical alignment. The second saddle was double-veed and simultaneously welded from each side. This variation in technique resulted in the elimination of the distortional effect, but, owing to the magnitude of the contract in comparison with the available skilled labour, it was decided to discontinue this "double" banking system. A procedure was therefore developed whereby single veeing from the fire side was used in conjunction with sets of restraint bars bolted across the saddle plate. The welding of the butts was carried out by the usual multi-pass and step-back oscillation technique, and the expansional closure of the butt gap was minimised by the simultaneous opposition of fusional and progressional direction. The back flanges of the removed furnaces were found to be scant as compared with the landing widths of the replacement and therefore the water side of each was heavily reinforced by welding to produce a wider surface and a close fit at the caulking edge.

ANNUALS AND REFERENCE BOOKS.

Birmingham Exchange Directory.—The 1947 edition of the *Directory of Members, Subscribers and Representatives of the Birmingham Exchange* has recently been issued by authority of the Committee of the Exchange. The particulars given for each member firm or subscriber include the postal and telegraphic addresses, the telephone number, the nature of the business or service carried on, and the names of the representatives. This section is followed by an alphabetical list of holders of tickets of admission to the Exchange, showing the firms whom they represent, while, in a final section is set out an alphabetical classification of the professions and trades of member firms. Apart from the directory sections, the book also contains some interesting information regarding the origin and development of the Exchange, which was founded in 1861 and incorporated in 1880. Shorter sections deal with the by-laws of the Exchange, the names of its officers and Committee, lists of books and periodicals in its reading rooms and reference library, and a list of officers of the various Divisions of the National Coal Board. Copies of the *Directory* may be obtained on written application to the secretary of the Exchange, Stephenson-place, Birmingham, 2.

Index to A.S.T.M. Standards.—As is the case with the British Standards Institution and other bodies engaged on standardisation, the American Society for Testing Materials publish annually a subject and numerical index to the specifications issued by them from time to time. The latest *Index to A.S.T.M. Standards*, which has been corrected to December, 1946, has recently come to hand; it contains particulars regarding 845 standard specifications and 544 "tentative" specifications. The former comprise those specifications which have been formally adopted by the Society, the measures taken for this, including approval by the entire membership by means of a letter ballot. Tentative standard specifications, as the name implies, are issued by the Society on the recommendation of the committee concerned, and opportunity is given for discussion or criticism, prior to their final adoption. All the specifications have been indexed under the principal subjects covered, while the numerical list is for use when only the specification number is known. The *Index* also contains particulars of other technical publications issued by the Society, lists of officers and standing committees and brief information on the purpose and work of the Society. The *Index* is bound in stiff-paper covers and copies are obtainable gratis on application to the Society, 1916, Race-street, Philadelphia, 3, Pennsylvania, U.S.A.

MAXIMUM-DEMAND ALARM INDICATOR.—During the fuel crisis at the beginning of the year, the Glacier Metal Company, Limited, Alperton, Middlesex, installed a warning system which gave audible indication that the permissible maximum demand had been exceeded. This system consisted of an ammeter, which was connected in one of the phases and was fitted with contacts which were set to close when the demand increased above a predetermined value. A relay connected in the contact circuit was then operated and, in turn, actuated a buzzer. To ensure that the alarm was not given on instantaneous overloads, a thermal delay switch was fitted, which delayed the sounding of the alarm until the permissible demand had been exceeded for more than three minutes. Such an arrangement is, of course, only applicable when the voltage remains reasonably constant and the load is evenly distributed between the three phases. We understand, however, that in practice it has worked well and has caused unessential plant to be switched off.

16-TON MINERAL WAGONS; L.M.S. RAILWAY.

THE department of the chief mechanical engineer, Mr. H. G. Ivatt, M.I.Mech.E., of the London Midland and Scottish Railway Company, have recently arranged plant in the carriage and wagon works at Derby for the large-scale manufacture of wagons involving a considerable amount of welding. The plant is now being used for building 2,000 16-ton all-steel open mineral wagons, one of which is illustrated in Fig. 1, on page 368.

In 1923, the unit-assembly principle for the production of wagons was introduced in the L.M.S. Derby works, the first type of wagon to be produced under this scheme being the 12-ton open wagon with timber underframe and body. Mineral wagons with steel underframes and wooden bodies, manufactured in a similar way, were adopted generally in 1935. To meet the demand for wagons of increased capacity, a design was prepared in 1944 for an all-steel mineral wagon with a capacity of 16 tons, but having the same length and wheelbase as previous types. A prototype of this design was completed early in 1945, using standard steel underframe components as much as possible, but larger diameter axle journals and stronger spring gear were provided to conform with the increase in carrying capacity. The floor plates, of ½-in. steel, were welded directly to the underframe, and the two sides, end-door beam, and fixed end were assembled on the frame as separate units. All the doors, at the sides, one end, and the bottom, were fabricated from plate and rolled sections; and although these were sound in design and construction it was decided that, for the side and end doors, steel pressings would be neater and more easily constructed. Steel pressings are therefore being used for the wagons now in production, as shown in Fig. 1. During the construction of the prototype, the drawing office and shops co-operated in finding solutions to problems of distortion, inaccessibility of welds, awkward joints, etc. The vehicle was subjected to shunting, side- and end-tipping tests, which it passed satisfactorily.

The underframes, which are of standard Railway Clearing House riveted design, are built on the existing assembly line in the erecting shop. The main members are sawn to length, and straightened in mechanical ram-type presses. Double-head end-milling machines are used for machining the ends of the members, which are then passed to multi-head single-spindle drilling machines. Solebar assembly jigs, two of which are shown in the foreground of Fig. 2, on page 368, are used for holding the various brackets which are welded to the solebars. These brackets include T and angle sections to connect with the side stanchions and support the floor plate, the brake-lever guard bracket, side-door check-spring bracket, and doorway angle, some of which may be seen in Fig. 3, on page 368. As shown in Fig. 2, the solebar channels are kept on racks adjacent to the assembly jigs, and brought to the latter, as required, down hinged ramps. The channel is then held firmly and accurately in position by a stop at one end and a screw clamp at the other. The brackets are placed in position and held there by swing-over clamps, the nature of which will be apparent from Fig. 2. The jig may be rotated on trunnions about its longitudinal axis to permit down-hand welding for most of the runs, and it is provided with an adjustable truss to apply a slight camber to the solebar prior to welding. When the solebar sub-assembly is completed it is removed from the jig, the clamps being swung over for this purpose, and then placed in a trolley jig, which runs on rails, for hydraulically riveting the axleguards.

The underframe is assembled in stages on an assembly line which is illustrated in Fig. 3. A rigid stand at the first stage, shown in the foreground of Fig. 3, is used for temporarily bolting together the sub-assemblies of the underframe. The solebars are fed from the trolley jig to this stand, and the other sub-assemblies are placed in position by an overhead crane. When the frame has been bolted together it is lifted on to a wheeled trestle at the next stage for riveting. It is subsequently moved along on its trestle for erecting the springs, brake-gear, buffers and drawgear, and at the end of the assembly line it is lifted off the trestle (which is then returned to the beginning of the line) and lowered on to the wheels, axles and axleboxes. The brakes are adjusted, and the undercarriage is passed forward for painting and delivery to the body-building shop.

The body is built complete as a unit, ready for lowering on to the undercarriage, in a shop where three parallel bays, each 200 ft. in length, have been arranged solely for this purpose. The first two bays, where the body is built, are each provided with a 5-ton overhead crane running the full length of the shop, and the third bay, where the body is lowered on to the undercarriage and some final welding, fitting and riveting are carried out, is provided at one end with a 5-ton hoist for lowering the body, and at the other end with a ½-ton hoist for erecting the wagon doors. In order to leave as much floor space as possible for other purposes,

the electric-welding transformers are supported on platforms slung in the apex of the roof. The first bay is used for the production of body components. Storage space sufficient for four weeks supply of material is provided at one end, where two loaded wagons enter at a time, and the materials are unloaded by crane. Plates for making the floor of a wagon are brought from the store and placed on a table having several ball-bearings arranged as inverted castors, whence they are rolled on to roller pedestals adjacent to a 10-ft. guillotine, and, farther along the shop, to punching and notching machines. At the guillotine the floor plates are sheared to size, at the punching machine drain holes are punched, and at the notching machine the plates are notched to fit the side stanchions. They are then given a coat of oxide primer paint on the underside, and passed to a storage stage, whence they are fed transversely, on roller trestles, into the second bay for assembly. Side and end plates are prepared in a somewhat similar manner. The machine section of the first bay is equipped with a cold saw, a horizontal milling machine, a radial drilling machine, and a straightening press, which are used in the production of body-framing members.

The second bay is arranged for assembly and welding of sub-assemblies and of the complete body. Considering the bay from one end to the other, side and end doors are unloaded from the wagon which has delivered them at one end of the bay; they are then passed to one or other of several welding jigs. Farther along the bay, are jigs and fixtures for the fixed ends of the wagons, for the sides, for tack-welding the whole body, and for final welding of the body. The components for assembly, as already noted, are brought through from the first bay on roller trestles, and the plant in both bays is laid out to ensure a simple flow of the work in this manner. Some of the jigs, for example the one shown in Fig. 4, on page 372, may be rotated through 360 deg. about the longitudinal axis, and in such cases contact brushes are fitted to the trunnions to obviate arcing when welding. The jigs for sub-assemblies reduce hand fitting to a minimum, and ensure interchangeability in subsequent jigs or fixtures. Rotating jigs are used for welding stiffener web plates in the side angles, gussets in side stanchions, end-door pins to end stanchions, and stiffening webs for end-door reinforcing channels. Fixtures are used for the bottom doors and side doors. Fig. 4 shows the jig for welding the wagon sides.

The body-shell, consisting of the floor plates, sides and ends, is tack-welded together in the fixture shown in Fig. 5, on page 372. The two larger floor plates are fed from a stack in the first bay at the rear, on rollers which are elevated, to assist the movement of the plates, by means of toggle-operated levers. The plates are fixed by stops and secured by quick-acting clamps on the fixture. The side and centre floor plates (which may be seen in Fig. 6, on page 372), are placed in position against stops which ensure the accuracy of the openings for the two bottom doors, and the side and end sub-assemblies are lowered into position and secured by swing-over clamping arms, as shown in Fig. 5. The shell is then tack-welded just sufficiently to ensure a rigid body which may be transferred to one of the two final-welding jigs. Each of these rotating jigs, or "manipulators," one of which is shown in Fig. 6, consists of two rings mounted on rollers and embracing the ends of the body. The jig is designed to ensure that the centre of gravity of the body and jig combined is approximately coincident with the axis of rotation of the jig, thus permitting two men to rotate the assembly as required for welding. Each ring is "broken" at two joints for inserting the body, and there is a choice of eight positions of the jig for welding. While the body is still in the jig, the underside of the floor plates is given a coat of black bituminous paint, and on removal from the jig, the body is transported to the third bay of the shop on a rail trolley, where it is lifted off and lowered on to the underframe, as shown in Fig. 7, on page 372. The wagon is then passed along through several stages on the shop road, where, successively, the underside of the body is welded to the underframe with intermittent runs on the frame members and a continuous fillet-weld between the floor plate and headstock at the door-less end; some further painting is carried out; and bottom doors and release gear, side and end doors are fitted. On an adjacent road in the same (third) bay the exterior of the body is cleaned and painted, wagon markings are applied, and the wagon is finally inspected.

No. 6 s.w.g. electrodes and alternating current are used for welding throughout the construction of the body, which requires about 470 ft. run. The weight of each body component is: body size, 1,024 lb.; fixed end, 545 lb.; end channel, 248 lb.; end door, 607 lb.; side door, 202 lb.; bottom door, 119 lb.; and the total weight of the body is 5,400 lb. "Spot" inspections are carried out on detail and sub-assembly work, and welding operators are subjected periodically to tests to ensure efficient work.

ALL-STEEL MINERAL WAGONS; L.M.S. RAILWAY.

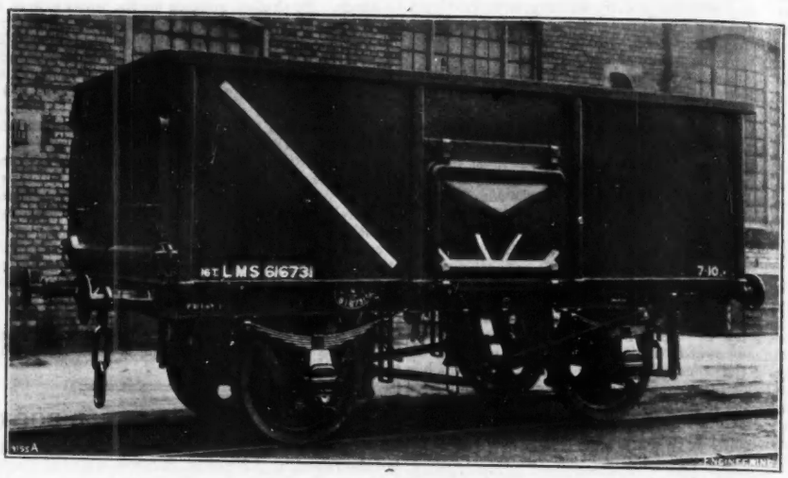


Fig. 1. 16-Ton All-Steel Wagon.

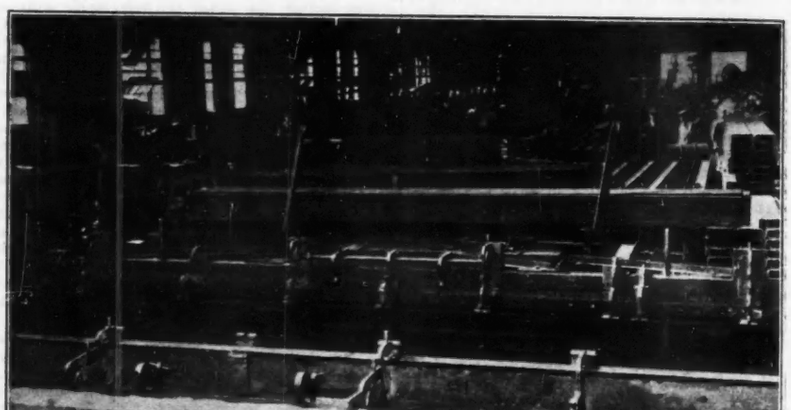


Fig. 2. Solebar-Assembly Jigs.

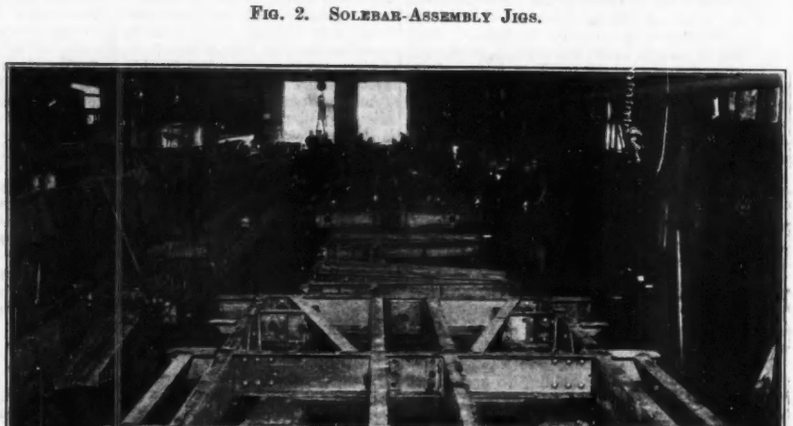
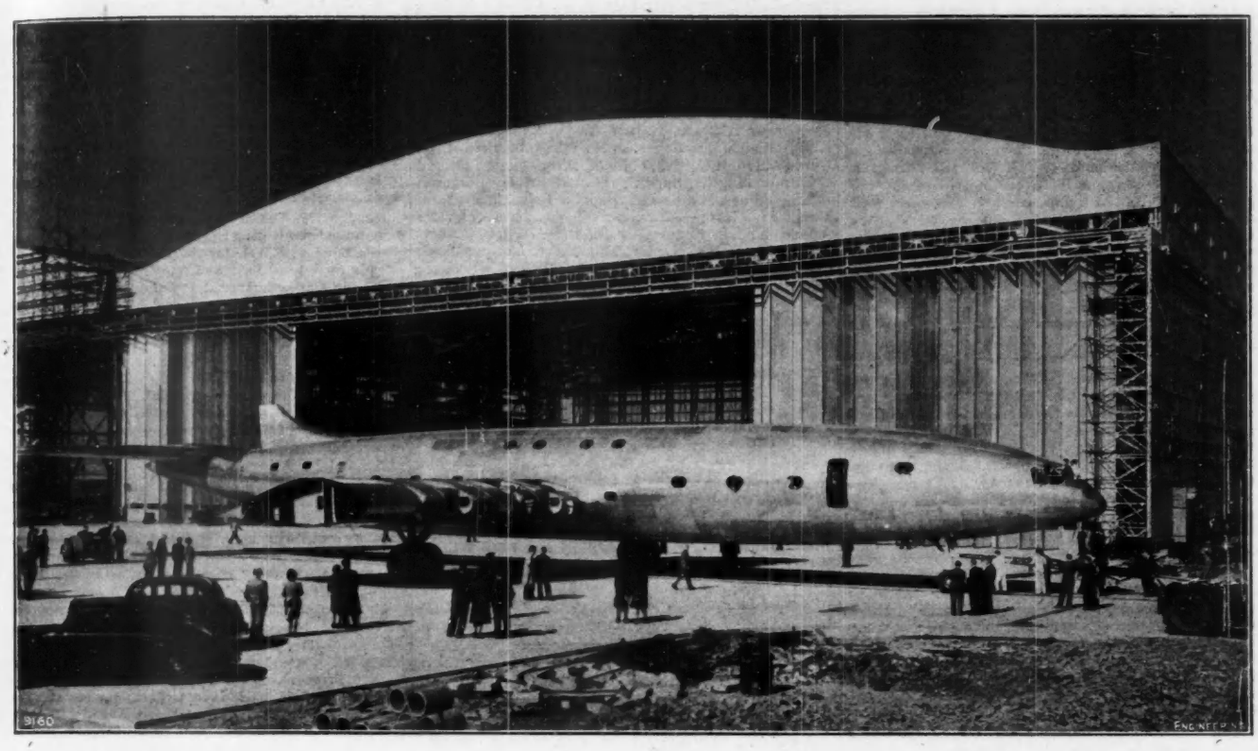


Fig. 3. Underframe-Assembly Line.

THE BRISTOL "BRABAZON" AIRCRAFT.

MESSRS. BRISTOL AEROPLANE COMPANY, LIMITED, FILTON.



THE BRISTOL "BRABAZON" AIRCRAFT.

As briefly recorded on page 351 of our last week's issue, the prototype Bristol Brabazon aircraft has now reached an advanced stage of construction and was moved recently to completed bay of the new assembly hall which is being built at Filton for the production, erection and flight testing of this type of aircraft. It will be remembered that the Brabazon, which is being constructed by Messrs. Bristol Aeroplane Company, Limited, is the largest land plane to be built so far in this country and the facilities required, therefore, are much in excess of those existing and necessitated the construction of a special assembly hall. An impression of the magnitude of the undertaking both as regards the aircraft and the building can be gained from the photograph reproduced on this page, which shows the partly-constructed aircraft being towed on to the apron in front of a completed bay of the assembly hall.

Obviously, the erection of such a large structure as the assembly hall has taken a long time, and it is to the credit of the Bristol Aeroplane Company that, rather than wait for its completion, they decided to proceed with the construction of the aircraft so far as the facilities already in existence allowed, and by using an existing hangar, were able to reach the stage shown in the illustration while the assembly hall was being built. In view of the fact that neither the aircraft nor the assembly hall have been completed, it is proposed to give a broad outline only of both projects at this stage.

As will be seen from the illustration, the Brabazon is a low-wing monoplane; it has been designed primarily for the North Atlantic service of the B.O.A.C., and possibly other long-distance services of the Corporation. The aircraft has a span of 230 ft., an overall length of 177 ft., and a height over the rudder of 50 ft., while the fuselage has a maximum diameter of 16 ft. 9 in. The completed aircraft will have an all-up weight of some 126 tons, and it is obvious that a considerable amount of research work will have to be undertaken on a machine of such proportions. The prototype, or Mark I, machine, therefore, will not be put into regular airline service, but will be employed solely on flight development work. It will be powered by eight Bristol Centaurus 18-cylinder sleeve-valve air-cooled radial engines, each of which is rated at 2,500 brake horse-power for take off. The engines will be housed in the inner wing forward of the front spar and will be enclosed completely, thus permitting inspection while the aircraft is in flight. The engines are arranged in pairs and each engine will drive one component of a 16-ft. diameter contra-rotating co-axial six-bladed Rotol airscrew. Each airscrew will be self-contained and have its own constant-speed, feathering and pitch-reversing mechanism, the last-named being for braking after the aircraft has touched down. The maximum continuous power for each engine when in medium supercharger gear will be 2,190 brake horse-power at 5,000 ft., and the maximum weak-mixture cruising power in full gear, 1,640 brake horse-power at 22,000 ft.; the maximum climbing power will be 2,190 brake horse-power. The tricycle-type undercarriage will be hydraulically operated, the nose wheel, just visible in the illustration, retracting backwards into the fuselage, while the main wheels retract forwards into the wing; in this connection, it is interesting to note that the maximum depth of the wing section is 6 ft. 6 in. The fuselage will be pressurised for a length of 143 ft., and the production aircraft will be fitted to carry between 70 and 100 sleeping passengers, or 120 sitting passengers, in addition to which a crew of 12 will be carried Passenger and crew accommodation will be mainly on one deck, but there will be a half-deck rise over the wing, where it passes through the fuselage, and this deck will be used for a dining saloon, lounge bar, kitchen and stewards' pantry; the dressing rooms and toilets will be beneath this deck. The flight deck will comprise stations for two pilots, a navigator, engineers and the radio operator, and the crew's rest room, toilet and sleeping quarters will be immediately aft of the flight deck. The prototype machine is scheduled to undergo initial flying trials during the early summer of 1948, and the Mark II, or first production aircraft, on which work is already proceeding, may be expected to be in operation by 1952. The production aircraft, however, will be powered by Bristol Proteus propeller gas-turbine engines having a considerably greater output than the Centaurus and, therefore, the Mark II machine should have a correspondingly better performance.

It will be realised from the foregoing that the size of the aircraft alone necessitates an exceptionally large hangar or assembly hall, and as previously mentioned, this is now in course of erection at Filton. As will be seen from the illustration, one wing, or bay, of the hall has been completed and eventually this will be used as the flight shed; at present, however, it is being used for the assembly of the prototype machine. When completed, the hall will consist of three bays, the central bay being somewhat longer than the two wing bays. The central bay, part of which can be seen under construction on the extreme left of the illustration, will be used for fabrication and sub-assembly work. the left-hand bay, as viewed from the front, for final assembly, and the right-hand bay, as previously mentioned, as a flight shed. The three bays have been arranged to open on to the apron through continuous sliding-folding aluminium doors, and the overall width of the whole building will be 1,052 ft. Each bay will have a maximum available width of 331 ft., while the overall length of the centre bay and the two wing bays will be 420 ft. and 270 ft., respectively.

Most of the steelwork is now in position and the size of the hall has resulted in many novelties in its design and construction. Arch ribs are spaced at 50-ft. centres and these span the bays to give the clearances of 331 ft. referred to previously. The seating pins for the arch ribs have a diameter of 10 in. and are located 2 ft. 6 in. below the floor level in open inspection pits. The distance from centre to centre of any pair of seating pins is 358 ft. and each rib rises vertically to eaves 82 ft. above floor level, after which it swings over to the apex of the arch, which is 116 ft. above floor level. The ribs are of lattice box-girder construction, each having a depth of 14 ft.; they are similar in design for all three bays, but vary in width, those for the outer bays having a width of 8 ft., whereas those for the centre bay have a width of 6 ft. By adopting these dimensions, it has proved possible to nest the vertical legs of the ribs dividing the bays one within the other, a unique form of construction which gives complete structural independence, and therefore freedom of movement for each bay. The vertical legs for each arch are connected to each other by ties, which are joined to the legs at a point near the level of the shoulders of the arch ribs, the height of the ties from the floor being 75 ft. The framing between the main arch ribs is of orthodox design; intermediate lattice girders span the bays between the main ribs and these carry subsidiary girders and purlins for supporting the roof, the ribs being braced transversely by deep lattice-type girders. The cranage system will be confined initially to the centre bay, but the two side bays have been designed so that similar installations can be fitted at a later date. Four independent crane beams will be arranged so that each covers a quarter of the centre bay width and two crabs will be provided, each having a lifting capacity of 12 tons. It will be possible to lock the crane beams

together at any point in the length of the bay, so that the crabs can cross over or be used as a pair.

The size of the joint project has given rise to many problems, not least of which was the removal of the prototype aircraft from its erecting hangar to the completed bay of the assembly hall. The side of the hangar in which the fuselage, wing centre section and tailplane were assembled was interrupted midway along its length by a support stanchion which prevented the aircraft from being drawn out in a lateral direction. It proved necessary, therefore, to pivot the aircraft through 90 deg., and this was accomplished by building an eccentrically-mounted turntable on the hangar floor on to which the starboard undercarriage wheel was moved and then clamped in position. The aircraft then was swivelled about the turntable and at the two critical points which occurred during the operation the clearance between one tip of the tailplane and the wall of the hangar was 2 ft. 4 in., while the clearance between the nose and another wall was 1 ft. 3 in. It is interesting to note that the complete removal was accomplished by a team of five men, consisting of the foreman, the tractor driver, two nose-wheel steering-arm operators, and an aircraft-brake operator.

LAUNCHES AND TRIAL TRIPS.

M.S. "Rajah Brooke."—Twin-screw passenger and cargo vessel, built by the Caledon Shipbuilding and Engineering Company, Limited, Dundee, for the Sarawak Steamship Company, associated with the Singapore Straits Steamship Company, Singapore. Main dimensions: 250 ft. by 47 ft. 6 in. by 26 ft. 3 in. to shelter deck; deadweight capacity, about 1,800 tons. Two Diesel engines of 1,920 aggregate brake horse-power, supplied by Messrs. Atlas Diesel Company, Limited, Wembley, Middlesex, to give a service speed of 13 knots. Launch, September 30.

M.S. "Braga."—Single-screw cargo vessel, with accommodation for 12 passengers, built and engined by Messrs. William Doxford and Sons, Limited, Sunderland, for Sociedade Geral de Commercio e Transportes, Limitada, Lisbon. Main dimensions: 424 ft. overall by 53 ft. 9 in. by 25 ft. 6 in.; deadweight capacity, about 7,000 tons. Doxford four-cylinder opposed-piston oil engine, to give a service speed of over 13 knots. Launch, September 30.

M.S. "Lotorium."—Single-screw tanker built and engined by Messrs. Harland and Wolff, Limited, Belfast, for the Anglo-Saxon Petroleum Company, Limited, London. Main dimensions: 446 ft. overall by 54 ft. 3 in. by 31 ft. Harland-B. and W. six-cylinder four-cycle Diesel engine. Launch, September 30.

S.S. "Jaljawahar."—Twin-screw general cargo and passenger vessel, built by Messrs. Swan, Hunter, and Wigham Richardson, Limited, Wallsend-on-Tyne, for the Scindia Steam Navigation Company, Limited, Bombay. Main dimensions: 430 ft. by 61 ft. 6 in. by 39 ft. 2½ in. to shelter deck; deadweight capacity, 7,500 tons on a draught of 25 ft. Triple-expansion four-crank engines with six single-ended oil-fired boilers, supplied by the Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne, to give a service speed of 14 knots. Launch, September 30.

S.S. "Besseggen."—Single-screw cargo vessel, built by Messrs. William Gray and Company, Limited, West Hartlepool, for Rederiet Besseggen A/S, Oslo. Main dimensions: 310 ft. by 46 ft. 10 in. by 27 ft. 10½ in. to shelter deck; deadweight capacity, about 3,400 tons on a draught of 19 ft. Triple-expansion engine supplied by Messrs. George Clark (1938), Limited, Sunderland, to give a service speed of 12 knots. Launch, October 1.

M.S. "Sunlit Waters."—Single-screw drifter-trawler, built by Messrs. Cochrane and Sons, Limited, Ouse Shipbuilding Yard, Selby, Yorkshire, for Mr. F. E. Catchpole, Lowestoft. Main dimensions: 96 ft. by 21 ft. by 10 ft. Diesel engine supplied by Messrs. Crossley Brothers, Limited, Manchester. Launch, October 2.

M.S. "Karnak."—Single-screw general cargo vessel built and engined by Messrs. Harland and Wolff, Limited, Belfast, for Messrs. Moss Hutchinson Line, Limited, Liverpool. Main dimensions: 345 ft. by 52 ft. by 32 ft. 6 in. to shelter deck; gross tonnage, about 3,350. Harland-B. and W. six-cylinder single-acting four-cycle Diesel engine. Launch, October 2.

S.S. "Orcades."—Twin-screw passenger refrigerated and general cargo liner, built, engined and boilered by Messrs. Vickers-Armstrongs Limited, Naval Construction Works, Barrow-in-Furness, to the order of the Orient Steam Navigation Company, Limited, managed by Messrs. Anderson, Green and Company, Limited, London. Main dimensions: 711 ft. length overall (668 ft. b.p.) by 90 ft. 6 in. by 50 ft. depth moulded to "E" deck; gross tonnage 31,000, draught 31 ft. Two sets of Parsons geared turbines with four Foster Wheeler water-tube boilers, developing 42,500 maximum shaft horse-power, to give a speed of 22½ knots. Launch, October 14.

INSTITUTION ELECTIONS.

Institution of Civil Engineers.

Associate Member.—William Rees Davies, Caernarvon; Douglas James Dawson, Hinckley, Leicestershire; Charles Johnson, Newcastle-upon-Tyne; Reginald William Percival Quirk, St. Albans; Richard Henry Reason, B.Sc. (Eng.) (Lond.), Leamington Spa; William Edward Haslam Sloan, B.Sc. (Manch.), Egerton, Bolton; Henry Rowland Walton, B.Sc. (Eng.) (Lond.), Bradford.

Student to Associate Member.—John Baliol Bentley, B.Sc. (Eng.) (Lond.), Neyland, Pembrokeshire; James MacGregor Bloomer, B.Sc. (B'fast), Armagh, N. Ireland; Alan John Boyce, B.Sc. (Bristol), Bristol, 6; Gordon Clifford Cottrill, Solihull, Birmingham; Donald Creed, Wallington, Surrey; Donald Brinley Ferguson Evans, Pinner, Middlesex; Douglas Reginald Fasham, Margate; George Alexander Flook, Liverpool, 23; Arnold William Hendry, Ph.D., B.Sc. (A'deen), Aberdeen; James Mills Henry, Milnathort, Kinross-shire; Charles Mervyn Johnston, B.Sc. (B'fast), Belfast; Daniel Angus Lochray McLarty, Bishopbriggs, Glasgow; John Edward Turner, Huddersfield; Donald Leslie Yipp, B.Sc. (Eng.) (Lond.), Ilford, Essex.

Institution of Mechanical Engineers.

Graduate to Associate Member.—Captain Arthur George Powney, R.E.M.E., B.A.O.R.; Denis John Ryley, B.Sc. (Eng.) (Lond.), Loughborough; Captain Fred William John Saar, R.E.M.E., Cardiff; Lieut. (E) Eric Southworth, R.N., Bolton-le-Sands, Lancs.; Edward Raymond Squire, Sheffield; Major John Hope Sturdee, B.A., Shrivenham; Arthur Sutcliffe, Oldham; George Melvin Ward, B.Eng. (L'pool), Rugby; Joseph Henry Wardle, Newcastle-upon-Tyne; Francis Julian Roy Watts, Brighton; Matthew Allan White, Paisley; John Whitehurst, Manchester; Alan Foster Wilson, Wallsend-on-Tyne; Desmond Maurice Young, Pretoria, S. Africa.

Student to Associate Member.—Robert Denis Jones, Leeds.

BOOKS RECEIVED.

The Oakwood Library of Railway History. No. 4. *The Maryport and Carlisle Railway.* By Professor Jack Simmons. The Oakwood Press, 30, White Horse-hill, Chislehurst, Kent. [Price 4*s.* paper; 5*s.* cloth bound.]

Department of Scientific and Industrial Research. Chemistry Research. Special Report No. 6. *A Study of Mechanically Produced Foam for Combating Petrol Fires.* By Dr. N. O. Clark. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* 6*d.* net.]

Symposium on Internal Stresses in Metals and Alloys, Held in London, 15th and 16th October, 1947. Organised by The Institute of Metals, in association with various other technical societies. The Secretary, The Institute of Metals, 4, Grosvenor-gardens, Westminster, London, S.W.1. [Price 5*s.*, post free.]

Symposium on Metallurgy of Steel Welding. British Welding Research Association, 29, Park-crescent, London, W.1. [Price 10*s.*]

Guide to Broadcasting Stations. Long and Medium-Wave Stations of the European Zone, and Short-Wave Stations of the World. Third edition. Compiled by the *Wireless World.* Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 1*s.* net.]

The British Association of Chemists. Education in Chemistry. The Teaching of Chemistry in Schools and the Training of Chemists and Chemical Technicians for Industry. Offices of the Association, Empire House, 175, Piccadilly, London, W.1. [Price 2*s.*]

Water Supply and Sewerage. By Ernest W. Steel. Second edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 6 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 30*s.*]

Production with Safety. By A. L. Dickie. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 2·50 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 12*s.* 6*d.*]

Electricity for Coal-Mining Students: General Principles and Application. By J. Stevenson and W. Miller. Second edition, second impression. The Technical Press, Limited, Gloucester-road, Kingston Hill, Surrey. [Price 8*s.* 6*d.* net.]

Fundamentals of Electricity and Electromagnetism. By Professor Vernon Andrew Sutdam. Fourth printing. D. van Nostrand Company, Incorporated, 250, Fourth-avenue, New York, 3, U.S.A. [Price 5·50 dols.] Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 27*s.* 6*d.* net.]

Bacon's Commercial Engineering. By James Bacon. Crosby Lockwood and Son, Limited, 20, Tudor-street, London, E.C.4. [Price 7*s.* 6*d.* net.]

PERSONAL.

The Lord President of the Council has appointed Professor P. I. Dee, C.B.E., F.R.S., who occupies the Chair of Natural Philosophy, University of Glasgow, and was formerly superintendent, Telecommunications Research Establishment; and Sir William Griffiths, D.Sc., F.R.I.C., F.Inst.P., chairman and managing director, Mond Nickel Company, Limited, and a past-president, Institute of Metals, to be members of the Advisory Council for Scientific and Industrial Research. Sir Lawrence Bragg, O.B.E., F.R.S., Sir John Lennard-Jones, K.B.E., F.R.S., Sir Andrew McCance, F.R.S., and Sir Raymond Streat, C.B.E., have retired from the Council on completion of their terms of office.

Mr. E. W. Senior, who, as stated on page 226, *ante*, has been elected by the Cutlers' Company of Hallamshire to succeed the Hon. R. A. Balfour as Master Cutler, was installed in Sheffield on October 7.

Dr. J. W. T. Walsh took office on October 14 as President of the Illuminating Engineering Society, 32, Victoria-street, London, S.W.1, for the 1947-48 session. He has already served one term as President; this was in 1929. The Leon Gaster Memorial Premium of the Society for 1947, consisting of ten guineas and a certificate, has been awarded to Mr. J. S. Smyth, for his paper, "The Brightness and Legibility at Night of Road Traffic Signs."

Mr. A. W. Manser, B.Sc. (Eng.) (Lond.), senior production engineer (Acton Works), London Passenger Transport Board, since April, 1946, has been appointed assistant mechanical engineer (workshops) in the department of the Chief Mechanical Engineer (Railways) of the Board.

Mr. Sidney B. Watkins, M.Sc., F.R.I.C., A.M.I. Chem.E., who has been Head of the Fuel Technology and Chemical Engineering Department at the School of Mines and Technology, Treforest, Pontypridd, Glamorgan, for many years, has been appointed Director of Chemical Engineering Studies, King's College, Strand, London, W.C.2.

Mr. Geoffrey C. R. Eley, C.B.E., has been appointed a director of the National Gas and Oil Engine Company, Limited, Ashton-under-Lyne.

Mr. W. L. Chance, J.P., who has been chairman of Chance Brothers, Limited, Glass Works, Smethwick 40, near Birmingham, since 1929, has relinquished the chairmanship but remains a director of the company and of its associated companies. Sir Hugh Chance has been elected chairman of Chance Brothers, Limited.

Dr. B. Edgington, B.Sc. (Lond.), F.R.I.C., has been appointed chief chemical engineer to Boots Pure Drug Company, Limited, in succession to Mr. H. Calam, who has retired.

Mr William S. Robertson, M.B.E., B.Sc., at present second-in-charge of the recently-formed Intelligence Section, Department of Scientific and Industrial Research, has been appointed Scientific Contacts and Industrial Information Officer to the Scottish Council (Development and Industry), St. Andrew's House, Edinburgh, 1.

Mr. Victor Berry, formerly on the staff of the Institution of Automobile Engineers, has joined the United Africa Company (Managing Agency), Limited, Unilever House, Blackfriars, London, E.C.4, to undertake the recruitment of mechanical and automobile engineers for the East-African scheme for the mechanised production of groundnuts.

Mr. G. J. Metcalfe, M.Sc.Tech., has joined the staff of the Fulmer Research Institute, Limited, Stoke Poges, Buckinghamshire, and has taken charge of the work on corrosion.

Mr. A. W. Cross, for the past five years a fuel efficiency officer of the London Midland and Scottish Railway, has retired after completing 49 years' railway service.

Mr. D. McLean, B.Sc., is now in the Metallurgy Division of the National Physical Laboratory, Teddington.

Mr. J. W. Garton, secretary of Messrs. Brown Bayley's Steel Works, Limited, Leeds-road, Attercliffe, Sheffield, 9, has been elected a director of the company. Mr. J. H. Merry, assistant secretary, has been appointed acting secretary.

Mr. H. F. Carpenter, F.C.I.S., clerk and manager of the West Midlands Joint Electricity Authority and this year's President of the Council of the British Electrical Development Association, has been appointed secretary to the British Electricity Authority.

Mr. G. H. Hale has been appointed assistant foundry manager, Messrs. Frederick Newman and Company, Limited, ironfounders, Lever-street, Wolverhampton.

Mr. E. H. Stagg, F.C.I.S., secretary to Sulzer Brothers (London), Limited, 31, Bedford-square, London, W.C.1, has been appointed a director of the company.

Messrs. Charles Churchill and Company, Limited, Coventry-road, South Yardley, Birmingham, have entered into an agreement with S. A. Joseph Petermann, Moutier, Switzerland, whereby they will manufacture, under licence, certain models of Petermann automatic machines.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—The two dominant features in the Scottish steel industry continue to be lack of fuel and lack of scrap. Deliveries of coal are coming back to normal after the recent pit strikes and holidays, and a meagre margin is available for restocking. The scrap position is so bad that it may yet be necessary to have recourse to the increased use of pig iron, with a consequent increase in production costs; that is assuming that the fuel position permits such a use of pig iron, which is doubtful. Against these difficulties, the demand shows no signs of decreasing and even the recent sharp advance in export prices has not resulted in any falling off in foreign inquiry. Re-rollers of bars and light sections have been receiving adequate supplies of billets and have maintained the production levels of recent months. The production of sheets is well below the demand, owing to the lack of sheet bars, and this is particularly unfortunate now when the demand for light sheets is higher than that in any other branch of the industry. Slabs are plentiful for heavy sheets, and full-time work is the rule. Tube makers are busy.

Scottish Coal.—The prospects of an increase in coal production look brighter than has been the case for some time. Apart from the extension of the working week, there has been a slight increase in the output per man-shift. Another encouraging feature has been that Lanarkshire is now free of major stoppages for the first time for over a fortnight. These features have made for steadier production during the past week and deliveries to all priority users have been at full scheduled levels. Steelworks have received their usual day-to-day needs, with very narrow margins for re-stocking, following the recent strikes and holidays, when winter stocks had to be used to keep up production. Coke ovens have recovered the leeway due to the same causes, and it has been possible to replace some stocks. A further cargo of American industrial coal is now due in the Clyde. Coastwise movement of coal continues on recent lines. There are regular allocations to the Admiralty dockyards from Methil and one or two cargoes a week to London. About 1,000 tons of slurry are going to Eire weekly and the movement of bunkers from Ayrshire, Fife and the Lothians continues, although on a more restricted basis. Cargoes to Ulster are also restricted, but are moving comparatively smoothly.

Scottish Shipbuilding.—The shipyards' scheme to stagger working hours entails Saturday work, and there is substantial evidence that many of the men will meet the requirement. For the purposes of the scheme, the yards have been divided into five groups, each with a different half day, and so far as it has been operated, the turn out for work has been described as "somewhat better than the usual Monday morning." The men apparently appreciate the necessity to spread the work over more than five days.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Mr. Edmund L. Hann, chairman of the Powell Duffryn Company, in his annual statement to the shareholders, makes the comment that if compensation arising out of the nationalisation of the industry were completed within four years from the vesting date he would be agreeably surprised. The balance sheet of the Powell Duffryn Group shows that assets valued at 12,253,789*l.*, previously belonging to the company, had been vested in the Coal Board, while assets amounting to 8,338,890*l.* had not been vested. A delegate conference of Welsh miners is to be held in Cardiff next week to initiate steps for the application of voluntary overtime work either by longer shifts or by a Saturday-morning shift. The improvement shown in outputs from the South Wales mines since the conclusion of the holidays at the end of August has been maintained. The latest figures available showed that, in the week ended September 27, the output of saleable coal raised was 421,100 tons, which was 100 tons more than in the previous seven days. Provisional figures for the week ended October 4 placed the output at 432,100 tons. Trading conditions have been extremely difficult on the Welsh steam-coal market throughout the week. The increases in outputs have been inadequate to meet requirements and, once again, sellers have been unable to take full advantage of the demand from home sources. Practically the whole of productions of all descriptions was disposed of to this trade, the bulk being taken by the public-utility and other high-priority consumers whose requirements will be very heavy for some months to come. As a result of the shortage of coals, none could be spared for general shipment abroad, in spite of the fact that a number of consumers in foreign countries showed a steady interest. Limited quantities were available for certain customers in Eire and Canada. Patent fuel and cokes were in brisk request from home users but supplies were difficult to arrange for delivery over some time to come.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Some new labour is being drafted into steelworks, which were about 1,000 short of full strength. Staggered hours of working are in operation at many works to conserve fuel and ease transport, but their institution has added to the disorganisation of production for the time being. Gas supplies are increasing a little and ensuring fuller operations at the heat-treatment furnaces. Electricity supplies are adequate, and there is a growing production at the electric-melting furnaces. Coke for blast-furnaces and crucible-steel melting furnaces is needed in larger quantities; there is insufficient iron and steel scrap for re-melting. After a prolonged dispute, the steel-melters who refused to operate the new scheme of working hours, designed by union leaders and employers to bridge the week-end gap under the shorter working week, have decided to operate the scheme. They had been given notice of dismissal from their union. Coal supplies are inadequate, and efforts to make up the loss of production resulting from the "stint" dispute is a slow process. All makers of steel products are short of steel: the rolling mills and forges are not receiving enough steel to provide the sheets and bars urgently required. Some additional labour is being provided to fill the gap of about 1,000 in the steelworks. Order books are well filled in steel, engineering and tool works, and provided sufficient fuel and steel come forward, a growing production of all types of steel products would be possible.

South Yorkshire Coal Trade.—A one-day dispute, now awaiting settlement by N.C.B. officials, has reduced coal production a little. Generally, the miners are working with a will and exceeding targets in some instances. It has been possible to keep the reserves at electric power stations up to a satisfactory level, and there has been a better flow of coke-oven gas through the South Yorkshire Gas Grid now that coke-works are operating fully. The make of coke is being steadily increased. Additional transport charges have caused a revision of coal and coke prices; coal prices have risen 10*d.* a ton and hard coke 1*s.* 10*d.* a ton. Allocations of house coal are smaller.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Increasing difficulty in allocating supplies of iron and steel over the last quarter of the year is perturbing. Drastic cuts are being made in the distribution of tonnage for non-priority purposes and even priority buyers are finding difficulty in securing deliveries sufficient to deal satisfactorily with their current needs. The aggregate tonnage output, however, is steadily increasing, and continued supplies of raw materials are fairly satisfactory. The output of local ironstone remains at a low level, but deliveries of native material are coming to hand from mines in other iron centres and imports of high-grade foreign ore are maintained on a very substantial scale. Pig iron is still wanted in larger quantities than are obtainable and the shortage necessitates the continued exceptionally heavy use of iron and steel scrap at foundries and steel furnaces. The use of scrap is large and increasing, resulting in substantial savings in fuel and helping to keep down works costs, but supplies are likely to be curtailed by the contemplated cuts in capital expenditure which will stop the breaking up of old plant and machinery. All finished commodities are in very strong request.

Foundry and Basic Iron.—The scarcity of ordinary foundry pig iron continues to retard the production of much needed commodities. Plants turning out light castings, in particular, are in urgent need of more foundry iron. Substantial quantities of basic iron are passing directly from the blast-furnaces to the producers' adjacent consuming plants, but still larger deliveries would be welcome.

Hematite, Low-Phosphorus and Refined Iron.—Manufacturers of East Coast hematite are able to cope satisfactorily with the demands for increasing supplies against running contracts. Bookings, however, are on a scale that will keep the furnaces in full production for a considerable time. The demand for low- and medium-phosphorus grades of iron continues to be much in excess of supplies, but refined-iron firms are handling their delivery obligations satisfactorily.

Manufactured Iron and Steel.—Semi-finished and finished-iron manufacturers have substantial bookings and steel producers are very extensively sold. The shortage of steel semies is less acute than of late, but makers are still unable to deal adequately with the requirements of the re-rolling mills. All available parcels of inferior material are readily accepted and consumers of sheet bars and billets are keen buyers of foreign products. Much larger quantities of finished commodities than are obtainable are required. The demand is greatest for shipbuilding requisites, railway material, colliery equipment and all classes of sheets.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North-Eastern Radio Group:* Monday, October 20, 6.15 p.m., King's College, Newcastle-upon-Tyne. Address by Mr. V. Z. de Ferranti. *Mersey Centre:* Monday, October 20, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. "Electrical Control of Dangerous Machinery and Processes," by Mr. W. Fordham Cooper. *London Students' Section:* Monday, October 20, 7 p.m., Victoria-embankment, W.C.2. Chairman's Address on "Radio Wave Propagation," by Mr. E. M. Hickin. *South Midland Centre:* Tuesday, October 21, 6.15 p.m., The English Electric Company, Limited, Stafford. Report on "Practical Training of Professional Engineers." *East Midland Centre:* Tuesday, October 21, 6.30 p.m., Electricity Showrooms, Derby. "The British Grid System in War-Time," by Messrs. J. Hacking and J. D. Peattie. *Transmission Section:* Wednesday, October 22, 5.30 p.m., Victoria-embankment, W.C.2. Chairman's Address, by Professor W. J. John. *North-Western Radio Group:* Wednesday, October 22, 6.30 p.m., Engineers' Club, Manchester. "Speech Transmission," by Dr.-Ing. D. Gabor. *Southern Centre:* Thursday, October 23, 6.30 p.m., Technical College, Brighton. "Ultra-High Speed Relays," by Messrs. W. Casson and F. H. Last.

INSTITUTION OF MECHANICAL ENGINEERS.—*Midland Graduates' Section:* Monday, October 20, 7 p.m., James Watt Institute, Birmingham. "Industrial Heat Utilisation," by Mr. D. C. Gunn. *North-Western Administration and Production Group:* Thursday, October 23, 6.45 p.m., Engineers' Club, Manchester. "Lapping and Honing," by Mr. J. H. Williams. *Institution:* Friday, October 24, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Presidential Address, by Lord Dudley Gordon. *Scottish Graduates' Section:* Friday, October 24, 7.30 p.m., Royal Technical College, Glasgow. "The Gas Turbine," by Mr. J. Milne.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, October 21, 5.30 p.m., Great George-street, S.W.1. "Modern Aids to Navigation by Radio," by Mr. H. E. Hogben. *Newcastle-upon-Tyne Association:* Tuesday, October 21, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. Debate on Multiplicity of Technical Societies.

INSTITUTE OF REFRIGERATION.—Tuesday, October 21, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, S.W.1. "Construction in Low-Temperature Insulation," by Mr. S. H. W. Richards. "Sandwich Construction for Insulation," by Mr. A. Cooper.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 21, 6.30 p.m., 39, Elmbank-crescent, Glasgow. "14-ft. Gear Hobbing Machine," by Mr. B. Barback.

INSTITUTION OF THE RUBBER INDUSTRY.—Tuesday, October 21, 7 p.m., Caxton Hall, Victoria-street, S.W.1. "Vulcanisation," by Dr. G. F. Bloomfield.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, October 21, 7 p.m., 198, West-street, Sheffield. "The Manufacture of Sponge Iron," by Mr. Ekstorp.

ROYAL UNITED SERVICE INSTITUTION.—Wednesday, October 22, 3 p.m., Whitehall, S.W.1. "Allied Air Power in the Mediterranean," by Air Marshal Sir Hugh Lloyd.

ROYAL AERONAUTICAL SOCIETY.—Thursday, October 23, 6 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "High-Temperature Alloys for Gas Turbines," by Sir William T. Griffiths.

INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, October 23, 6 p.m., 11, Upper Belgrave-street, S.W.1. Presidential Address, by Mr. F. S. Snow.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*London Associate Members' Section:* Thursday, October 23, 6.30 p.m., Junior Institution of Engineers, 39, Victoria-street, S.W.1. "Small Heating Pumps," by Mr. G. V. Engert.

INSTITUTE OF METALS.—*Birmingham Local Section:* Thursday, October 23, 6.30 p.m., James Watt Institute, Birmingham. Discussion on "Significance of Mechanical Testing."

JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 24, 6.30 p.m., 39, Victoria-street, S.W.1. "The Willans Engines," by Commander E. W. Willans.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, October 24, 6.45 p.m., Engineers' Club, Manchester. "Fabricated Methods of Oil-Engine Construction," by Mr. J. Botwright.

INSTITUTION OF PRODUCTION ENGINEERS.—*Yorkshire Graduates' Section:* Saturday, October 25, 2.30 p.m., Midland Hotel, Bradford. "Cost Control for Management," by Mr. R. Cooper.

INSTITUTE OF BRITISH FOUNDRYMEN.—*East Midlands Branch:* Saturday, October 25, 6 p.m., Leicester College, Leicester. Various papers on "Foundry Problems."

CONSTRUCTION OF 16-TON ALL-STEEL MINERAL WAGONS; L.M.S. RAILWAY.

(*For Description, see Page* 367.)

FIG. 4. WAGON-SIDE WELDING JIG.

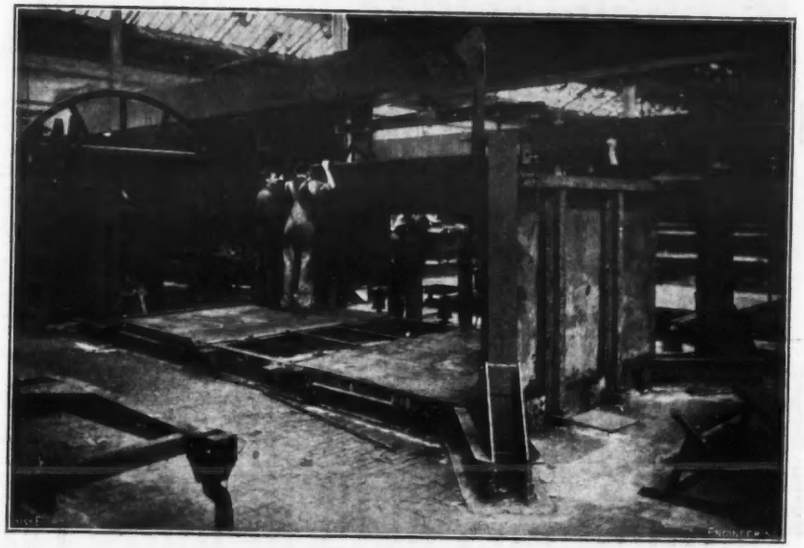


FIG. 5. BODY TACK-WELDING FIXTURE.

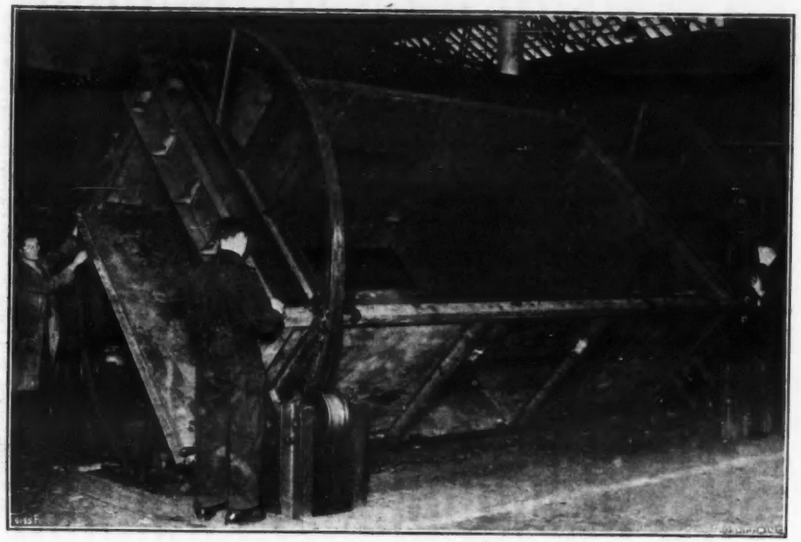


FIG. 6. ROTATING JIG FOR FINAL WELDING OF BODY.

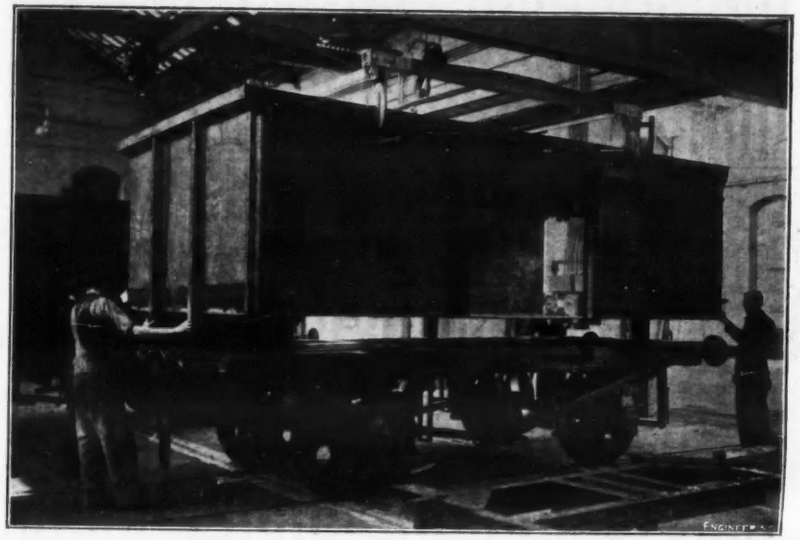


FIG. 7. LOWERING BODY ON TO UNDERFRAME.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

INDEX TO VOL. 163.

The Index to Vol. 163 of ENGINEERING (January-June, 1947) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY, OCTOBER 17, 1947.

VOL. 164. No. 4264.

STANDARDISATION IN INDUSTRY.

IT is natural and appropriate that Mr. Percy Good should have devoted the greater part of the inaugural address which he delivered as president to the Institution of Electrical Engineers on Thursday, October 9, to the subject of standardisation. It is natural because standardisation is a subject to which, as he said, he has devoted half his life; and it is the prerogative of presidents to draw on past experience for their themes. It is appropriate because the Institution, for many years, has played an active part in the preparation of standards. In fact, as far back as 1885 it set up a committee for this purpose. Four years later, moreover, it recommended to the Government the establishment of a laboratory for calibrating electrical measuring instruments and continued directly to do useful work in this field through a committee on which "the manufacturer, user, consulting engineer and the user's engineer were represented." Later it was associated with four other leading engineering bodies in the foundation of the organisation now well known as the British Standards Institution, which grew out of a committee set up by the Institution of Civil Engineers to prepare standards for steel sections. It is common knowledge that this organisation has enabled every section of industry to co-operate in the establishment of standards, while retaining its own autonomy; and has created a machine possessing the highest qualities of democracy and usefulness, which is available not only to industry as a whole, but also to the Government.

The work of the British Standards Institution is now so familiar to engineers and the results of its activities are so widely known and accepted that there is some risk that the desirability, not to say the necessity, of its functions under present conditions, may be obscured. Mr. Good was, therefore, well advised to enunciate some of the principles underlying the conception of standardisation, and to point out that the term involves more variety and complexity than is always realised. It may be said, in fact, that standardisation fundamentally has its roots in ethics. This is clear from the ancient statutory order which reads, "Thou shalt not have in thy bag divers weights a great and a small. Thou shalt not have in thy house divers measures a great and a small." In other words, the main objective of a national standards movement is not, as is often supposed, the fixing of sizes, but the establishment of criteria of quality, fitness and performance. The stimulus to such a movement in relatively modern times had also its ethical basis, since it was due to a reaction from the deterioration in trading conditions which arose at the beginning of last century. At that period, commerce had too often become a free-for-all battle in which a trader had for his antagonists his competitors in the same industry, with the employees and consumers as unwilling and almost helpless participants. There was, as Mr. Good pointed out, practically "no co-operation within industry; there was war between rival producers; war between workers for a job and there was war against technical progress." As the century entered its last quarter, however, matters began to improve, partly owing to a realisation that trading could not be carried on according to jungle law and partly owing to an awakening of the national conscience to the necessity for establishing humane industrial relationships. Further, the fact that standards were essential to secure fair competition between traders, if there was not to be general decay, began to be recognised. Once again indeed the truth of the old adage that honesty is the best policy was illustrated.

Industrial standardisation, as it exists to-day, may then be broadly defined as a process which enables the properties that are significant for determining the suitability or value of a product to be assessed in comparable terms. An analysis of the present industrial standards shows that they can be divided into those concerned with quality, *i.e.*, fitness for purpose or performance; with dimensions; with sampling and certification marking; and finally with terms, definitions and symbols. To set up a standard of quality, the function that the material or article concerned is required to perform must be discovered; and frequently what it should not do must also be found. Although it is not difficult to state the answer implied in these requirements in general terms, it is sometimes impossible to give it in a form which is capable of measurement. Until that has been done, however, a really satisfactory standard cannot be laid down. In fact, an ideal standard is one in which requirements are stated in terms of such mechanical, physical and chemical properties as can be assessed objectively. This is not always possible at present, but Mr. Good held out the prospect that research would alter this in time.

The second, or dimensional, class of standards is usually designed to secure interchangeability, to establish a range of types and sizes, or to provide a means of defining functions. Interchangeability, of course, plays the important role in modern industry of enabling parts from many sources to be brought together. In domestic life, too, it facilitates the replacement of worn out or damaged parts; and in both spheres has made a great deal of headway. Although much yet remains to be done in this direction, in many industries the resistance to it, which still persists in some quarters, is not, as Mr. Good pointed out, necessarily prompted by self-interest. It is often due to the fear that replacement parts from other sources than the original factory may be unsuitable or inferior. The remedy, of course, is in general not to oppose standardisation, but to take steps which will allow an appropriate specification to be prepared. In other words, a general increase in the quality of the product is the goal. Another branch of dimensional standardisation is concerned with the important problem of eliminating unnecessary types and sizes. Mr. Good gave some striking examples of the extent to which this has been done already, mainly perhaps as the result of war conditions. The field covered is very wide and may be said without exaggeration to extend into almost every branch of human activity. We agree with him, however, that the time has come when an organised inquiry should be made into this matter from the economic point of view; and that the best means of securing the general adoption of the standards that have been or will be prepared should also be considered. If this is not done, a great deal of the effort that has been expended will be in some danger of being wasted.

Although the inspection of small samples in order to judge the value of the bulk is an ancient and not highly scientific practice, in comparatively recent times mathematical treatment has enabled methods to be devised which ensure that the samples fairly represent the stock from which they are drawn. As a result, the use of certification marks on goods, where testing must be carried out on samples, has become practicable. In this connection it may be pointed out that, while the use of certification marks is governed by the Trade Marks Act and certification marking is therefore not an inherent part of industrial standardisation, the two are becoming increasingly associated as a result of the desire to distinguish standard from non-standard goods. Certification marking, such as the historic hall-marking of gold and silver articles, also conveys information which the purchaser is entitled to have and which he can accept with the assurance of its validity. It has, moreover, the advantage that if the producer is operating an effective system of statistical control, sampling can be used as an assurance that the bulk of the goods conform to the standard. A large inspectorate, such as is necessary, for instance, for marking by weight or volume, need not therefore be employed.

The final branch of standardisation dealt with by Mr. Good was that of nomenclature. In considering this he remarked that loose terminology caused a loss both of efficiency and commercial integrity in the chain of transactions from raw material to the ultimate consumer. As he also correctly pointed out, the meaning of a scientific, technical, or trade term used to describe a material or property should not depend upon the context. Standard glossaries are therefore required, the function of which is to fix one meaning. They are thus to be distinguished from dictionaries, the function of which is to give all the accepted meanings of a word. The compilation of these glossaries, if they are to have full value, is a task which should be carried out under international rather than national auspices; and in the case of new scientific and technical terms there are, as Mr. Good observed, many sound reasons for attempting to secure that these should be the same in all the principal languages. As it is, some progress has been made unconsciously in this direction, for, according to Ogden, there are already some 600 scientific and technical words which, when written in most languages, are sufficiently alike to be generally recognised.

There are, however, two important omissions from Mr. Good's address, of which mention may be made. Nothing is said in the printed version about the way in which the work of standardisation is organised, although the subject was dealt with cursorily at the meeting. This is a pity, because we feel sure that it is not generally known how many subjects are covered. It would also have been interesting to hear something of the actual procedure whereby the cognate specifications are prepared; for we do not think it is commonly realised to what a large extent this depends on the work of committees recruited from the industries concerned or that the labour, more often than not, is voluntary. Neither is it recognised how well the resulting specifications illustrate that spirit of compromise for which the British are allegedly famous. The efficiency of a committee, frequently with some justice, is considered to be low; but that so large a number of specifications on a great variety of subjects are produced every year in this way shows that there are exceptions to this rule. It would have been interesting therefore to know how it is done.

The second omission suggests some lack of the critical spirit. It is nowhere admitted, even by implication, that there may be cases where standardisation in all its facets is not yet universally desirable. Mr. Good would probably agree with this; but it might have been as well to mention that too early standardisation may sometimes act as a check to progress. There would have been no risk in doing this since standardisation, in its broadest sense, is clearly of the highest value. That this is recognised is shown by the widening scope of the British Standards Institution; and there is no doubt that the work of this body, properly applied, will do a great deal to strengthen the structure of industry.

GEOLOGY IN THE COALFIELDS.

A KNOWLEDGE of geology forms part of the mental equipment of mining engineers, and, indeed, of most civil engineers, but the activities of even the former cover so wide a technical field that geology necessarily cannot constitute more than a section of their professional interests. It may act as a background control of much of their work but it is not their main preoccupation; they are essentially engineers, not geologists. In a paper read before the Second Pan-American Congress of Mining Engineering and Geology in October, 1946, which was reprinted in abstract on pages 329 and 377 of our 163rd volume, Mr. Roger Rhoades made a case for employing geologists *per se* in connection with civil-engineering works which involved extensive excavation and foundations, and stated that the Bureau of Reclamation of the United States had about 100 employees on its geological staff. A plea for a procedure of the same type in the British coalfields was made by Dr. M. Macgregor in his presidential address to the Geology Section at the recent Dundee meeting of the British Association. He suggested that at least one trained and full-time geologist should be assigned to each major coalfield or coalfield area.

There is no suggestion that the information furnished by geologists has been neglected in the past. The mining maps prepared by the Geological Survey have been, and are, of great value to the mining industry, although many of these have been out of date for long, and do not embody information gathered in recent years. Dr. Macgregor stated that "there is a large body of geological data obtained from borings put down within the last twenty or so years as well as from underground developments which does not appear on any published map." The times are certainly not promising for the rectification of this state of affairs, but the consideration of printing and other difficulties was not the main subject of the address. The essential point put forward was that a team of geologists trained in coalfield work should form an integral part of the Geological Survey service, and should be assigned the task of carrying on and extending the work which the Survey, with its limited staff and multifarious duties, so far, has not been able to complete.

The setting up of the National Coal Board, and the unification of the whole of the colliery industry, should facilitate the carrying out of the proposals contained in the address. The whole of a coalfield, which has always been geologically a unit, has now also become one administratively and broader plans embracing greater areas may be worked out and carried through. These broader plans to be successful, however, must be based on accurate geological information. The building up of this body of information should be facilitated by the unification which has taken place. There are now no conflicting or competing interests to be considered in the interpretation of evidence; the relative economic and other considerations determining the best procedure in the development of a coalfield area can no longer be influenced by legitimate, but sectional, interests, and the new regime will permit a closer integration of the various problems of occurrence, structure, mining and marketing.

Dr. Macgregor pointed out that the geologist is the first link in the chain of technical service necessary for the exploitation of a coalfield. He is followed by the mining engineer, the chemist, and the fuel expert. No question of the relative importance of the various services rendered arises, but it is indubitable that the geologist occupies the first position. The Geological Survey has furnished the colliery industry with a series of six-inch maps which have been of unquestionable value, but, as already mentioned, many of these are long since out of date. Apart from the large amount of work involved in incorporating later information in the documents, printing difficulties would make it impossible to issue an entirely new series within a reasonable time. The new administrative conditions in the colliery industry, however, may do something towards easing the situation. It is pointed out that the present unified control will allow of concentration on areas or fields where early developments are projected, and it is suggested that it should be possible to revise the six-inch sheets for selected areas and to institute methods by which they might be frequently revised to incorporate new data as these become available.

This latter procedure would involve constant geological service of a type which the Geological Survey has not been able to render in the past. To maintain and continually extend a body of up-to-date geological information about a coalfield requires permanent liaison between the geologists concerned and those occupied with exploitation. Borings, shafts and underground workings must be inspected in a systematic way, and any information they may bring to light related to the general geological picture; a proper and broad-based synthesis of a coalfield cannot be built up on isolated investigations of single pits or relatively small areas. The trained and full-time geologist, whom it is suggested would be attached to each major coalfield, would be in a position to obtain the additional evidence on geological structure, which all mining operations furnish, and the team trained in coalfield work, which would form an integral part of the Geological Survey, would be in a position to utilise this information in establishing a more complete and truer body of knowledge about the geology of the coalfields as a whole. The limited staff and multifarious duties of the Survey do not at present enable it to carry out this work on the scale, and in the detail, which is desirable.

Such a service as that suggested would facilitate the establishment of more reliable estimates of coal resources. The various figures which have been put forward as representing the coal reserves of Great Britain were presumably based on such geological information as was available at the times they were formulated. They have varied greatly. A Royal Commission set up in 1871 estimated the total reserves by 1945 as 131,000 million tons; this figure was raised to 133,000 million tons by a further Royal Commission appointed in 1901; and in 1913, Sir Aubrey Strahan, of the Geological Survey, further increased the figure to 172,000 million tons. A still later figure, put forward by H. S. Jevons in 1915, was 190,000 million tons. Dr. Macgregor does not give these various totals, but refers to the matter generally and quotes *The Coal Resources of the World*, published by the Twelfth International Geological Congress held in 1913. The totals given in this return have been widely quoted in text-books, but Dr. Macgregor points out that the figures given for "actual reserves" in the Province of Alberta in Canada is 386,373 million tons, "probable reserves" being given as 649,833 million tons. As compared with these impressive figures, the *Report on the Coal Resources and Coal Industry of Alberta in Relation to Those of Canada*, published in 1945, gives the total of the available coal, *i.e.*, in seams of 3 ft. or more in thickness and within 1,000 ft. of the surface, at the more modest figure of 46,562 million tons.

Wide variations of this kind must make all estimates of this type suspect. To a considerable extent they are undoubtedly due to a lack of clear and generally agreed definitions, and Dr. Macgregor suggests that estimates of coal resources might usefully be divided into "proved" reserves, which have been revealed by existing underground developments and by borings; "partly proved" reserves estimated from borings and geological evidence; and "inferred" reserves, for which there is no valid evidence of the actual occurrence of workable seams. He thinks estimates of the latter type might usefully be expressed only in such general terms as "probably considerable" or "possibly large." Such a practice would eliminate the specific figures, which actually are nothing more than guesses, which are so frequently put forward. Broad estimates of the coal resources of the world are only of academic, or at least only of long-term, interest, but the "proved" and "partly proved" reserves of Great Britain are a matter of acute importance. They must form the basis of the whole development policy of the National Coal Board, and a special coalfield branch of the Geological Survey would greatly facilitate the accumulation of information.

NOTES.

CODES OF PRACTICE.

THE Minister of Works, Mr. C. W. Key, addressed a special meeting of the Institution of Gas Engineers at Gas Industry House, Grosvenor-place, London, S.W.1, on Friday, October 10, when the first issue of the new Codes was released by the Codes of Practice Committee for Civil Engineering, Public Works and Buildings. Dr. Harold Hartley, President of the Institution of Gas Engineers, was in the chair. The committee was established in 1942, as a result of negotiations initiated by the Ministry of Works, in consultation with the Ministry of Health and other Government departments. The chairman is now Mr. J. R. Beard, M.Sc. Its terms of reference are: to direct the preparation of codes of practice for civil engineering, public works, building and constructional work. The codes constitute recommended good practice, but are not mandatory. The principal professional and scientific institutions associated with this type of work are represented on the committee, as also are the British Standards Institution (which publishes the codes on behalf of the committee), and the Building Industries National Council; assessor members are nominated by certain Government departments, and the chairman is appointed by the Minister of Works. The programme of the committee embraces about 350 to 400 projected codes, on which over 60 sub-committees are working. One such sub-committee, convened by the Institution of Gas Engineers, and under the chairmanship of Lieut.-Colonel F. J. Bywater, M.C., M.I.C.E., M.Inst.Gas E., has completed ten codes, which constitute the first issue of the Codes of Practice Committee. These codes deal principally with gas services in private houses, because it was felt that the needs of the post-war housing programme should come first. The titles cover service pipes, metering and consumers' control, installation pipes, flues, gas lighting, domestic hot-water supply by gas, gas space-heating, cooking installations, gas-operated refrigerators, and the installation of gas-heated appliances for laundering and ancillary domestic purposes. Further information can be obtained from the secretary, Codes of Practice Committee, 42, Onslow-gardens, South Kensington, London, S.W.7.

THE COAL BUDGET.

The Minister of Fuel and Power (Mr. H. T. N. Gaitskell) presented a rather involved coal budget for the coming winter to a Press conference on Tuesday, October 14. He said that, on October 4, stocks amounted to 14,800,000 tons, and he thought that it was safe to reckon on 15,250,000 tons by the end of the month. The improvement over last year was due to the virtual elimination of exports, to lower internal consumption, and to higher supplies, nearly half of the latter, however, were imports. "We should not, therefore, pat ourselves on the back too soon." So far this year, production had amounted to 151,700,000 tons, and it looked as if another 46,000,000 tons could be obtained, making a total of about 198,000,000 tons for the year. During the summer, consumption had been about 3,000,000 tons less than was expected, so that although an output of 200,000,000 tons would not be reached, minimum demands might still be met. Between November 1, 1947, and May 1, 1948, it was estimated that 101,250,000 tons would be produced, compared with 97,500,000 tons last winter. In addition, 8,750,000 tons could be safely withdrawn from stocks, making an available total of 110,000,000 tons. Of this, 23,510,000 tons would go to large industrial consumers, 18,200,000 tons to merchants, 16,450,000 tons for the generation of electricity, and 13,750,000 tons for gas making. In addition, coke ovens would take 10,750,000 tons, railways 7,500,000 tons, and collieries 8,700,000 tons, leaving 8,340,000 tons for miscellaneous purposes and 2,800,000 tons for exports and bunkers. Besides the 23,500,000 tons for large industrial consumers, there would be an equivalent of 900,000 tons of coal in the form of fuel oil. The total supplies to industry would thus be 24,400,000 tons, or 23 per cent. more than was consumed last winter. About 11 per cent. more coal would go to the coke ovens and electricity and gasworks would also receive small increases. On the other hand, industry would not be able "to go all out" unless non-industrial consumers reduced their consumption by at least 10 per cent. To achieve this object, a fuel economy campaign had been started this week, in connection with which a conference was held at the Mansion House. At this, it was pointed out that if the rationing of electricity and gas had been practicable it would have been adopted long ago. The one thing we could not afford this winter, however, was any impediment to further production through lack of coal.

THE FUTURE OF ELECTRICITY SUPPLY.

In his presidential address to the Association of Supervising Electrical Engineers, which was delivered on Tuesday, October 14, Mr. H. Nimmo, discussed the Electricity Act, 1947, and said that, as regards nationalisation, prominent men in the industry had for years been trying to work out a suitable scheme for the reorganisation of distribution on evolutionary lines. It was now the duty of everyone to make the Act a success. For all practical purposes the Area Boards would be autonomous bodies free to use initiative and enterprise, and aiming to give their consumers the best and most efficient service. On the question of size and efficiency, although a number of small undertakings were efficient, the larger organisations ought to be able to give better service. No one had been able to define the optimum size, but it was feared that an undertaking might become too large to maintain personal contact with the consumer. He had never, however, heard it suggested that any of the large organisations in this country, in the United States, Canada or Europe were inefficient or that personal touch with their consumers was lacking. The question of dividing London into two or more areas had been investigated and the general conclusion had been reached that it could not be divided satisfactorily. In fact, efficiency, whatever the size, arose from expert management and the application of sound engineering principles. By and large the industry would be run by the same men, the only significant change being that of ownership. Given careful selection of the personnel of the Central Authority and the Area Boards, there was every reason to expect nationalised electricity to be successful. With high coal costs and other increased prices a general fall in the charges for electricity could hardly be expected in the early stages. On the other hand, some economies would be effected by the low rate of interest and by bulk purchases, and the benefits accruing must go to the consumers. He believed a good start had been made, and with close co-operation and goodwill on all sides, the conditions were favourable for making the electricity-supply industry of this country the most efficient organisation of its kind in the world.

SYMPOSIUM ON INTERNAL STRESSES.

As announced in our columns on page 322, *ante*, the "Symposium on Internal Stresses in Metals and Alloys," organised by the Institute of Metals, was opened at the Institution of Mechanical Engineers, London, S.W.1, on the morning of Wednesday, October 15, and was concluded in the afternoon of the following day. At the outset of the proceedings, Colonel P. G. J. Gueterbock, C.B., D.S.O., President of the Institute of Metals, welcomed the members of the societies which were co-operating in the work of the Symposium, namely, the Faraday Society, the Institute of Physics, the Institution of Mechanical Engineers, the Iron and Steel Institute, the Physical Society and the Royal Aeronautical Society. He stated that, in addition, the Société Française de Métallurgie had sent a delegate to the meeting. The symposium, Colonel Gueterbock said, had originated as a result of discussions held by the Metal Physics Committee of the Institute of Metals. These discussions had led to the conclusion that the time was opportune for bringing together engineers, metallurgists and physicists to discuss problems of common interest concerning all matters affecting internal stresses in metals and alloys. The methods employed during the war years could be discussed with advantage and the free exchange of ideas would act as a stimulus to research workers engaged in this field.

LETTERS TO THE EDITOR.

CREEP AND SHRINKAGE IN REINFORCED CONCRETE.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. H. B. Seed, in the paper reprinted on page 309, *ante*, comes to the conclusion, already proposed, that a higher modular ratio than at present should be used in the design of reinforced-concrete structures. He suggests a figure of 27, and says that "its use in design would lead not only to more accurate calculations of the stresses and deflections in reinforced-concrete structures at all ages after about one year, but also, by preventing the concrete stress from falling appreciably below its working value, to a more economic use of this material."

Let us consider the effect on column design of a modular ratio of 27. If we assume concrete of sufficient strength to allow a working stress of 1,140 lb. per square inch (Grade I, according to the Draft Code of Practice of 1946), the working stress on the steel would be 30,800 lb. per square inch. Since the permissible compression stress in mild steel is limited to 18,000 lb. per square inch, such a result could not be accepted. To keep the steel stress at 18,000 lb. per square inch, the working stress on the concrete would have to be limited to 667 lb. per square inch, that is, below the lowest stress specified in the Draft Code of 1946, which is 750 lb. per square inch for Grade III concrete. Thus, by raising the modular ratio, the opposite of Mr. Seed's expectation would be achieved. The purpose of this example is to demonstrate the absurdity of designing reinforced-concrete columns on the basis of a modular ratio. Indeed, as Mr. Seed has pointed out, "in a reinforced-concrete member, even under constant load, there will be a continuous redistribution of stress due to the progressively increasing creep and shrinkage deformations." The logical conclusion from this fact is that so-called "working stresses," worked out with an assumed modular ratio, have no significance whatever as a measure of safety or load-bearing capacity.

Experiments on columns under sustained design load have proved that, in certain cases, the actual stress in the steel may reach the yield point of the steel and the stress on the concrete become almost zero. Consequently, as was recognised long ago, the correct formula to design reinforced-concrete columns is

$$\text{Permissible load} = \frac{\text{Ultimate load}}{\text{Factor of safety}} = \frac{W}{f}.$$

The ultimate load is

$$W = A_c c_p + A_s y.$$

where A_c = sectional area of concrete; A_s = sectional area of steel; c_p = prism strength of concrete; and y = yield point of steel.

This method, which eliminates the modular ratio altogether, was introduced in the Code of Practice of 1934, but the L.C.C. By-Laws of 1938 still adhered to the old method, which was also adopted by the Code of the Building Industries National Council. The Draft Code of 1946 also accepts the old method.

The space available within a letter does not allow a similar demonstration of the absurdity of the standard method in the design of reinforced-concrete members subjected to bending. This was done by the writer ten years ago in a series of articles in *Concrete and Constructional Engineering*. The factor of safety of structures designed by the standard method varies inevitably within wide limits, whatever value is assumed for the modular ratio. A reliable and economical method of design has to be based on the ultimate load-bearing capacity of structures. Our present knowledge of the behaviour of reinforced-concrete structures is quite sufficient to determine this value with close approximation if the strengths of the concrete and steel are given. Only by relating the permissible load to the ultimate load-bearing capacity can a uniform

factor of safety be achieved, which is the necessary condition of an economical design.

Yours faithfully,
K. Hajnal-Kónyi.

7, The Park, Golders Hill,
London, N.W.11.
October 6, 1947.

THE MEANING OF MASS.

To the Editor of Engineering.

Sir,—In your issue of October 3, on page 327, *ante*, Mr. C. Hubert Plant indicated very ably the content of present-day conceptions of mass, energy and matter, and the way they are related. True, on analysis some of these conceptions as set out in his letter still present difficulties; for example, does a "body" (which is not defined) "possess" a certain arrangement of energy, or is this arrangement of energy itself the body? If the latter, does the additional energy required to promote motion of the existing arrangement of energy take the form of additional protons, neutrons and electrons in that arrangement of energy? Again, the idea of an arrangement of energy which has breadth without length may be a concept in the minds of Einstein and Mr. Plant, but it fails to form any image in my own mind. But this, no doubt, is because—as Francis Bacon put it—"the subtilty of the operations of nature far exceeds the subtilty of words."

However, the purpose of my letter was not so much to secure clarity for myself as to plead for greater clarity in the wording of text-books set before young students, together with abandonment in such works of definitions which are no longer in accord with modern conceptions. To this I would now add that, at the same time, students should be made to realise that scientific conceptions are never final; that, as Professor J. B. S. Haldane remarked recently, "In science, both natural and political, we never get the whole truth, and can never hope to. But we can always get a little nearer to it in each generation."

Yours faithfully,
Hugh P. Vowles.

The Leaze,
Oxlynch, Stonehouse, Glos.
October 11, 1947.

EMPLOYMENT IN SOUTH AFRICA.

To the Editor of Engineering.

Sir,—As a result of hearing the observations of a number of immigrants from England seeking employment with my company, may I offer the following advice to people hoping to make homes in South Africa?

(1) Do not speak disparagingly of England; it never helps in obtaining employment.

(2) Do not ridicule the methods of manufacture seen in South Africa; it seldom helps in obtaining employment.

(3) Do not demand senior positions; they are seldom given to newcomers.

(4) Do not state that dignity would be injured by accepting a lower starting salary than previously earned in England.

(5) Remember that most men in senior positions to-day started a long way down the ladder, and be prepared to follow suit.

(6) Remember that the new man must be tried out before allowing him to change methods or modify systems which are functioning often quite satisfactorily.

Perhaps I may point out, also, that rents are very high that all letting is controlled and that newcomers are placed at the bottom of a very long waiting list. A 5 or 6 roomed house in Durban costs approximately 4,000*l*. Shops are full of high-priced consumable goods, which makes living expensive, and the average income throughout the population is only 45*l*. per annum.

As I have no desire to be inundated with letters, I enclose my card and remain

Yours faithfully,
Technical Director.

Natal,
October 7, 1947.

THE OLD CENTRALIANS.

To the Editor of Engineering.

Sir,—It is proposed to form a Western Branch of the Old Centralians, based on Bristol, to provide a meeting place for former students of Finsbury College and the City and Guilds Engineering College who are living in the West Country and South Wales.

An inaugural meeting and dinner will be held at Hort's Restaurant, Broad-street, Bristol, on Thursday, October 23. The reception will be at 6.30 p.m. and the dinner at 7.30 p.m.; and the President of the Old Centralians, Mr. F. H. Bramwell, will be present, with several members of the Committee in London. Mr. A. C. Clinton, of 7, Worcester-crescent, Clifton, Bristol, 8, is acting as honorary secretary, pending the formation of the Branch. May we, through your columns, ask any Old Centralians in the West Country, who may wish to attend this meeting and have not already sent in their names, to communicate as soon as possible with Mr. Clinton at the above address.

Yours faithfully,
A. M. Holbein,
Hon. Secretary.

3, St. James's-square,
London, S.W.1.
October 14, 1947.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 332.)

We continue below our report of the autumn meeting of the Institution of Naval Architects, held at Portsmouth on September 23 and 24, and at Southampton on September 25 and 26. The third of the three papers discussed at Portsmouth—"Calculated and Observed Wave Resistances for a Series of Forms of Fuller Mid-section," by Mr. W. C. S. Wigley, M.A., and Professor J. K. Lunde, M.Sc.—was presented by Mr. Wigley at the morning session on September 24. Lord Chatfield again presided.

Wave Resistances for Forms of Full Mid-Section.

Mr. Wigley, in presenting a summary of the paper, explained that his calculations had been made some years ago, but that facilities for testing them by means of models were not available until the authorities of the Norwegian ship-model tank at Trondheim placed their resources at his disposal. The forms tested could have mid-section coefficients as high as 0·909. Four models were tested, and were formed by the addition of a bulge, with variable cross-section, to two of the forms belonging to the parent series, with uniform parabolic cross-section. The tests made at Teddington with the parent forms comprised the measurement of the resistance and the attitude over a range of speeds corresponding to values of Froude's number from below 0·16 to 0·54. The wave profile was photographed at a number of speeds and the centre profile aft of each form was measured for a distance of about 6 ft. Similar tests were made of the models run in the Norwegian tank, the resistance and attitude during motion being recorded automatically. The wave profiles were also measured by direct observation of their heights; and, finally, the model was painted with vertical stripes and run again, when the paint was drawn out into thin lines which showed approximately the wave profile and the direction of flow at each point. The results showed that a full mid-section, and the consequent rather flat bottom, did not cause more discrepancies between calculation and fact than occurred with finer mid-sections. The calculations had been made only for a ratio of draught to length of 1 : 16. It was felt that they should be extended to cover a ratio of 1 : 32, for which the necessary calculations were complete for the forms with parabolic cross-sections. As opportunity occurred, further experiments were desirable with models of both draughts.

Mr. R. W. L. Gawn, who opened the discussion, said that the results afforded further confirmation of the reliability of the mathematical methods so arduously and brilliantly pursued by Mr. Wigley. The inclusion of forms with a comparatively full midship-section coefficient, which more closely approached a normal form than the "peg top" parabola, was an advance; but there was scope for a still closer approach to practical ship shapes and he hoped that the authors would consider that in formulating future programmes. The results in the paper covered the top speeds of fast destroyers, but the dimensions and type of lines were not suitable for such vessels. One conspicuous difference was that the displacements of the models were fully twice as great as those appropriate to a destroyer; which, presumably, accounted for the excessive resistance coefficients of the models. It was possible that much work would yet have to be done to adapt the theory to a destroyer form, but it might not be so difficult to apply it to a form of destroyer dimensions. That would be of great value. The paper showed fairly close agreement between the theoretical and experimental results for the two models tested in the Norwegian tank, but an appreciable disparity at top speeds for the two models of parabolic section tested at Teddington. The authors sought to explain that by the smaller depth of the N.P.L. tank, quoting results which implied that a 4 per cent. difference could be attributed to depth effect. That, however, could only be accepted as an incomplete explanation for the large difference shown on the curves, which reached a maximum of 18 per cent. There was also a statement that the form effect on skin-friction resistance was greater for the models of parabolic section, compared with the fuller models. That was surprising, but possibly the disparity was due to some effect more fundamental than shallow water and form resistance. It was disturbing that closer agreement between theory and experiment was obtained with the fuller models than with those of lesser displacement; if that trend held, a greater difference might be expected for a model of ship proportions, which would be of smaller displacement. A stage had been reached in research where there was promise of possible reduction in skin-frictional resistance. The laminar-flow aircraft wing indicated one direction in which improvement might be sought, but there were many practical difficulties in maintaining laminar flow in a ship. The fundamental work on the shape most conducive to the maintenance of laminar flow had yet to be developed.

Dr. G. S. Baker said the paper was really an extension of that which Mr. Wigley had presented to the Institution in 1940, in which he had shown that his method of calculation could be adapted to calculating the effect of adding unsymmetrical features to a model hull. Until that time, all his calculations had been for symmetrical forms, and he had shown that, if those additions were of the parabolic 'midship section, he obtained adequate results indicating the effect produced on wave profile and resistance of the hull. In the present paper, he had taken a bulge on a 'midship section, altering the shape. Dr. Baker suggested that it would be valuable to publish all the papers on the subject together in one publication, to make a fairly complete whole.

Mr. Wigley, in his reply, said that improvement in skin friction really amounted to an improvement of what was called the form effect. He favoured the suggestion to publish in one volume the papers by Guilloton and himself, and was willing to do any work which might be necessary to amalgamate those papers to form a continuous whole.

This concluded the technical session on September 24, the afternoon being devoted to visits to the Cunard-White Star liner Queen Elizabeth and, by invitation of the Director, Captain G. W. Wakeford, to the School of Navigation at Warsash. Those who took part in the latter visit, as well as being entertained to tea and supper by Captain and Mrs. Wakeford, had the pleasure—enhanced by the fact that it was an unexpected addition to the programme—of a sail down Southampton Water in the School training vessel, the 103-ton ketch Moyana, manned by a crew of cadets.

The proceedings on the morning of Thursday, September 25, opened with a reception at the Civic Centre by the Mayor of Southampton, Alderman F. S. Smith, J.P. The President, in his introductory remarks, recalled that, during the war, he

had visited Southampton in his capacity of Special Commissioner for the Southern Region, to help the town in some of the difficulties resulting from enemy air attacks. He had another personal interest in the port, because it was used so extensively by the Royal Mail Steam Packet Company, of which his father had been chairman and managing director for 20 years.

The Mayor, in welcoming the Institution, observed that he was also Admiral of the Port, a position which, dating from 1451, carried jurisdiction over the waters of the Solent as far west as Hurst Point, and, to the east, up to and including Portsmouth. That jurisdiction, conferred by Henry VI, had never been rescinded. There was still an abundance of work for naval architects, and many establishments in the Southampton district where they would find much of interest.

The President then called on Mr. O. H. Lewis, the general manager of the Southampton Harbour Board, to present his paper on "The Port of Southampton."

THE PORT OF SOUTHAMPTON.

Southampton, said Mr. Lewis, possessed a great natural advantage in the double high tide, two high-water crests, separated by about two hours, occurring twice in each day. Various theories had been advanced to account for this phenomenon, most of the features of which could be reproduced by the method of harmonic analysis; they extended, with small modifications, to the adjacent coasts of France, and the Isle of Wight had little part in them. Since the Eighth Century it had been held by many that one wave came up the English Channel, causing the first high water; and the other, originating about 12 hours earlier, came round Scotland, down the North Sea and through the Straits of Dover, causing the second high water. The hydrographers of the Southampton Harbour Board had always maintained the substantial truth of this theory, although it did not explain completely some of the smaller features of the phenomenon, the causes of which remained in some obscurity.

Mr. Lewis then traced the history of the port from Roman times onward, pointing out that it was from Southampton that the Pilgrim Fathers sailed on August 15, 1620, in the 180-ton Mayflower; they only called at Plymouth. Throughout the Eighteenth Century, the port had to fight hard for its position, but the beginning of the Nineteenth Century was a period of great trade expansion, and, in 1838, the foundation stone of the first dock was laid. This was the Outer Dock, completed in 1843, and belonged to the Southampton Dock Company, the last undertaking of which was the Empress Dock, opened by Queen Victoria in 1890. Two years later, the London and South Western Railway purchased the docks, which passed into the hands of the Southern Railway in 1923 as part of the railway amalgamation of that year. In 1924 was begun what was probably the most ambitious scheme of dock extension ever undertaken in any British port, when the Southern Railway commenced to build an entire new system of docks, about two miles long and half a mile wide, from the Royal Pier to Millbrook Point. The additional quayside accommodation provided would take eight of the largest ships afloat in line, with a depth of water alongside nowhere less than 40 ft. at low water of ordinary spring tides. These facilities were used to the utmost during the war, the total net tonnage of shipping entering the whole port during 1944 being nearly 26,000,000, as compared with the pre-war record of 15,000,000 tons. From "D-day" to "VE-day" over 2,000,000 men of the United States forces were embarked at Southampton, and in all, in the invasion of Europe, the port handled 11,817,111 tons of cargo and 3,640,165 personnel.

Sir John Thornycroft, who opened the discussion, said that he had known Southampton for more than 50 years. Building the docks had been a good deal more difficult than similar work in many parts of the world, because the constructors had to get through the mud bottom before they could reach any sort of foundation. The Trafalgar Dock, he believed, was the first mass-concrete dock built in this country. No sooner was it finished, however, than the advent of bigger ships made it necessary for the dock to be widened. The largest ship at the close of the first world war was the Berengaria, which could only be docked there if her rudder were put hard over. When the next dock was constructed, a good margin was allowed for the Queen Mary and her sister. When the American Line ships first used Southampton, there were some of the smaller vessels which were not too well built. They were run very hard and had suffered from vibration, so that the bottom plating had leaked badly and the rivets in the double bottoms had hardened up after each voyage. To facilitate this frequent access, the people responsible for the repair work suggested cutting manholes in the bottoms of the ships. The Board of Trade and Lloyd's Register did not like the idea, but it was pointed out to them that there were manholes in boilers, so why should there not be in ships? In the end, they agreed and the manholes were cut in the bottoms. The south of England was also a shipbuilding as well as a ship-repairing centre. Around Southampton there was a number of small yards, and yards which could build fairly big ships. Since the war they had built in the area 40 or 50 vessels of considerable size for Governments abroad. Credit should be given to the far-sighted railway directors for going to the lengths they had in developing the port. There were many more schemes in preparation, for which they would not be responsible. The last job for which they would be responsible was to make a new terminal for the Cunarders to come alongside. It had been felt for a long time that sheds were not important enough for such ships, that people coming from abroad should arrive at a terminal which would impress them as had the ships in which they travelled. The railway officers who were carrying out the work, he believed, would produce, with their architects, a lasting memorial to the administration by the railway.

Mr. S. T. Cope, discussing a long-term policy for providing facilities for flying boats, thought that, with the construction of the designs now on the drawing board, history would repeat itself. The Cunard Company and the travelling public were not content until they had their "Queens," and he believed that the same sort of thing would happen in connection with air travel. The flying boats of to-day, with 30,000 to 40,000 lb. all-up weight, could utilise the facilities of Southampton Water; but in 20 years' time there might be flying boats of 300,000 or 400,000 lb. It was worth while to consider very carefully whether difficulties would then arise in providing full facilities for surface craft as well as aircraft.

Mr. Lewis, replying to Mr. Cope, said that the Southampton Harbour Board's scheme for an air terminal in the Solent was submitted to the Ministry of Civil Aviation, and was considered, along with others, by the Government. The Pakenham Committee, which was set up to examine the various schemes put up by port authorities throughout the country, had decided against the Southampton scheme, principally because of the presence of shipping; although, he contended, it was proved that the shipping interference was negligible. Alternatives were now being considered by the Government, but he believed that it had been proved conclusively that there was no better place for the purpose in the country than the lower end of Southampton Water.

(To be continued.)

PUBLIC ENGINEERING LECTURES, KING'S COLLEGE, LONDON.—Two courses of free public lectures are to be held at University of London, King's College, Strand, W.C.2. The first course, in the Department of Civil and Mechanical Engineering, will deal with "Mechanical Aids to Improved Thermal Operations," and will be given at 5.30 p.m., on Mondays, October 20 and 27, and November 3, 10 and 17. The first three lectures, and the last, will be delivered by Professor S. J. Davies, D.Sc., M.I.Mech.E., while the fourth, on November 10, will be given by Mr. L. J. Clark, B.E.M., B.Sc. (Eng.), A.M.I. Gas E., who will deal with special considerations in the production of gas for towns. The second course of lectures will be on "Limiting Factors in the Design of Electrical Machines," and will be delivered by Dr. R. Pohl in the Department of Electrical Engineering of the College, at 5.30 p.m., on the alternate Tuesdays, November 4 and 18, and December 2.

THE FUEL ECONOMY CONFERENCE.

(Continued from page 329.)

THE previous instalment of our report on the technical sessions of the Fuel Economy Conference, held at The Hague from September 2 to 9 under the auspices of the World Power Conference, dealt with the proceedings on September 3. On the following morning, two sessions were held concurrently in different halls of the Kurhaus at Scheveningen, covering Sections A4 (Gaseous Fuels) and C4 (Use of Energy for Transport Purposes). In the afternoon, at a single session, Section A5 (Electric Energy) was followed by Section C1 (Utilisation—General).

GASEOUS FUELS.

The *rapporteur* of Section A4 was Ir. J. J. Derksen, Director of Gas Supply in the Netherlands Ministry of Economic Affairs. His general report covered four papers only, as certain others had not been received in time for inclusion. The Fuel Expenditure Index, evolved by the Gas Directorate of the (British) Ministry of Fuel and Power, he considered to be a criterion worth adoption by other countries. The Index was a number representing the remainder after deducting, from 100 heat units of coal carbonised, the sum of the heat units in the products (gas, coke, tar and benzol); in other words, it was a measure of the heat expended and lost in the process of carbonisation. The same paper (that of Mr. T. C. Finlayson) contained valuable suggestions for preventing heat losses by the correct construction of regenerators and ovens, and the proper use of the various forms of heat recovery. The dry cooling of coke by using the incandescent coke for steam raising, as practised in Switzerland for many years, was shown to have various advantages; but, he inquired, were these advantages as real as they were represented to be, and, if so, why was the system not applied more extensively to large coke-oven plants and in other countries? Nothing was said about the first cost of the system. A study of gas production in association with the chemical industry was typical of a tendency, noticeable in the Netherlands, for a close co-operation between the gas-producing industries and other big coal-using industries, such as chemical plants and steel works. This tendency, said Mr. Derksen, emphasised the fundamental principle that coal must be regarded as a raw material rather than as a fuel. In the fourth paper of the Section, particulars were given of a steam-saving process for benzol extraction and solvent recovery by means of activated carbon; it was estimated that about 2 kg. of steam could be saved for each kilogramme of benzol. The comment was made on this and other processes, however, that the capital cost of initiating fuel-saving projects required to be studied carefully in the light of local conditions, such as the cost and efficiency of labour, which might vary widely; and that all of the fuel-saving methods proposed were seen at their best in large plants. Of one of the additional papers, received after the preparation of the main report, it was observed that, apparently, world fuel economy would benefit greatly by the development of underground gasification of coal; but further information seemed desirable regarding the practicability of applying this process to seams lying at depths of 500 m. or more. A report on coal-gas production in Italy showed that, after a period of almost complete cessation, it was being restored in 1947 to 80 per cent. of the 1942 output; but the calorific value was still much below the pre-war level.

ENERGY IN TRANSPORT.

Professor J. J. Broeze, who summarised the papers in Section C4, had to consider only three, two dealing with railways and one with ship propulsion; a response which, as he said, hardly did justice to the importance of transport as a cause of fuel consumption or as a field for fuel economy. Capital outlay often bulked too largely among the considerations involved in selecting a method of transport; there was always a tendency to cut down the initial expenditure, to the detriment of operational economy. A comparison of the two papers on railways, one

from France on steam traction, and the other, from Sweden, on electric traction, showed clearly that the days of steam were over; for the same gross output of work, the steam locomotive required from 2½ to 3½ times the coal that would be needed to maintain electric traction. Attempts to lower the consumption of the steam locomotive to any significant extent only led to complicated turbine-condenser systems, which were not favoured by the experts. The use of oil fuel in the inherently uneconomical steam locomotive was only a palliative, to relieve coal shortage. Substantial economy of fuel involved electric traction, using current generated by water-power, and any arrangement that could be made to provide this internationally was sure of an international welcome. Electrification greatly increased the capacity of a railway, but much of the extra traffic resulted from the improved facilities and it was a question then whether economy was an important argument. Little was said about Diesel traction in spite of its enormous expansion in the United States and parts of Europe, but it might be mentioned that the Diesel engine was supreme for branch-line and shunting operations. The figures given in the French paper, relating to the gas-turbine locomotive, would disappoint enthusiasts for this new development; its superiority over the Diesel engine in maintenance and versatility must be very marked to offset the difference indicated, though the use of inferior grades of fuel might do so. In brief, the guiding principles of railway operators all over the world had become electrification, with or without hydraulic power, for suitable lines, and "Dieselisation, if you will pardon the word," for the remainder. In the field of ship propulsion, it appeared that the emphasis in development had been on the boiler, the object being to increase the rate of heat transfer; and it seemed that the trend was towards higher heat-transfer by radiation and an increase of convection by raising the density and velocity of the gases. This interesting combination of effects seemed to imply a removal of part of the heating surface from the high-pressure (steam) part of the system to the low-pressure (air) part, to increase the air preheat. Professor Broeze did not accept, however, that the gas turbine was a novelty on shipboard; Diesel engine exhaust-gas turbines had been in use for fully 20 years. The great increase in Diesel machinery contemplated in France was noteworthy, as were also the persistent efforts to use boiler-grade fuel oils in such engines, but he considered that more thought should be devoted to the highly supercharged four-stroke engine and to an effective separation of the cylinder from the crankcase, to reduce corrosion effects. The influence of the fully-fledged gas turbine on marine propulsion had yet to be seen.

Electric Energy.

The section, to which was given the general title of "Electric Energy," was intended to cover the problems of generating, transforming and distributing electricity; but, although the scope of the section was so wide, there were only five papers listed in the programme, and apparently only three of these were available when Ir. C. Vos, the *rapporteur*, prepared his summary of them. One of these was the paper presented by the official British delegate, Sir Johnstone Wright, on "Co-ordination of Electricity Supply: the British Grid in War Time"; the others, from France and China, dealt, respectively, with an attempt to forecast the future loading of main transmission lines and with the past, present and future of the electricity industry in China. The difficulty which Mr. Vos evidently found in working the three papers into a connected report would seem to indicate the advisability, on a future occasion, of separating the section into two or perhaps three. The French paper he described as a "theoretical contemplation" of the development of transmission voltage in France, showing how hydro-electric power could be used in conjunction with steam-electric power, even when (as in France) the generating stations were not centrally situated. The paper was a discussion of a "technical-economical" problem, in contrast to the others, which dealt with actual war-time difficulties.

The British report on the war-time functioning of the grid, Mr. Vos continued, showed how a well-designed system of interconnection, based mainly on steam power stations, withstood the most severe air raids and, by its flexibility, enabled supplies of current to be maintained from and to any desired centre. Operational control, originally exercised through seven control points, was centralised in one. The outbreak of war caused first a temporary reduction in load, soon succeeded by an increase of nearly 100 per cent., with a peak load one-third above pre-war level. There were considerable transferences of load resulting from military requirements and the dispersion of industry, but an increase of about 10 per cent. in the grid lines enabled this to be met, even though the air-raid damage extended to some of the generating stations. The difficulties of operation were enhanced by the increasing average age of the plant, reductions in the quantity and quality of the coal used, and the problem of transporting the coal under war conditions. In China, however, the conditions were relatively much worse. In 1936, the installed capacity was 630 MW and the output was 1,700 million units; 90 per cent. of the capacity was in the coastal areas. When the Japanese occupied the coastal regions, only the small factories could be evacuated to the interior and the only modern power stations left to the Chinese were in Chungking and two other cities. Where possible, new equipment was made locally, and water power was exploited to a limited extent. The hope that Manchuria and Formosa would provide power for the reconstruction of Chinese industry was not realised; new generating plants in Manchuria were dismantled by the Russians, and others were destroyed by Communists and bandits, so that only 15 per cent. remained. The post-war electricity scheme provided for an addition of 2,000,000 kW, two-thirds in steam plants and one-third hydro-electric. The intention was to carry out this scheme, but the more urgent need was to repair the existing systems. The next step would be the construction of 12 networks, combining steam-power and water-power, and covering the whole country.

General Report on Fuel Utilisation.

Only one paper was submitted in Section C1, this dealing with the utilisation of the sources of power in France. Professor F. K. Th. van Iterson, in his report, explained that this apparently poor response was due to overlapping with the series of special reports on "Fuel Economy since 1939"; indeed, the solitary paper, which was contributed by Mr. P. Salmon, of the French Ministry of Industrial Production, might well have been included among that series. It quoted statistics concerning the use of various fuels in France, in industry and for domestic purposes, from 1939 to 1946, and discussed the various possible methods of improving the efficiency of utilisation, including the use of infra-red radiation for heating. The author did not overlook the possibility of improving efficiency by such measures as superheating and the employment of higher steam pressures, back-pressure turbines, etc.; but, as the *rapporteur* observed, France had suffered too much to be able to lead the world in a campaign for improved combustion, decreased heat losses and more careful plant maintenance, and offered less opportunity than the United States, for example, to install large boiler units with pulverised-coal firing, water-wall furnaces, and other aids to economy. He commended to French engineers, however, the methods of the British Fuel Efficiency Committee as a way to prevent small losses due to the human factor.

The consideration of Professor van Iterson's report concluded the technical sessions held on September 4, and no more were held until the morning of September 8, when Section A6 (Atomic Energy) was taken, followed in the afternoon by Section B2 (Distribution of Liquid and Gaseous Fuels). No paper was submitted in Section B1 (Distribution of Solid Fuels), which was also to have been discussed on that day. Two days of the week-end period between the two groups of technical sessions were occupied by an admirably organised visit, by special train, to the State Mines in Limburg and the adjacent nitrogen-fixation plant.

Atomic Energy.

For the first time in its history, said Dr. H. Brinkman, in reporting on Section A6, the World Power Conference was faced with the problem of the production of nuclear energy and the prospects of its economic application; but thereafter the potentialities of atomic power must recur as an important subject in the discussions of subsequent World Power Conferences. He hoped that those future discussions would show that it had been developed exclusively for the public welfare. Apart from the present lack of information, due to official secrecy, the physical and engineering problems involved were entirely new and many years must elapse before they could be solved. The three papers submitted—American, English and French—were presented by writers of authority, but the lack of detailed information resulted in many uncertainties in the technical and economic analysis. Though none of the papers about nuclear power generation revealed any facts that had not been published elsewhere, together they gave a fairly complete review of the subject.

In a nuclear reaction, only U235, Pu239 and U233 could act as nuclear fuel. The fission process liberated as heat 24·5 kWh per kilogramme of the fissile material entering into the reaction, this being about 3×10^6 times the energy obtainable by burning an equal weight of coal. For constructive purposes, the energy release must be controlled; this was achieved in the slow-neutron reactors, consisting of short rods of natural uranium or of material enriched with U235 or Pu239, regularly distributed within a large graphite block of suitable dimensions. It might be possible, also, to use thorium (Th 232) mixed with one of the nuclear fuels previously mentioned. The rate of energy production depended on the equilibrium concentration of the extremely diluted neutron gas inside the reactor, and the operation of a pile could be regulated by inserting or withdrawing rods of cadmium or some other strong neutron-absorber. The heat generated in the metal rods was transferred by using a liquid or a compressed gas as a cooling medium; Dr. J. D. Cockcroft, the British contributor to this Section, mentioned helium and CO_2 as suitable gases of low neutron absorption. The cooling agent circulated through a heat exchanger, a steam-raising boiler, or directly through a gas turbine. The whole reactor, including the heat-transfer circuit, must be enclosed in steel and thick walls of concrete to insulate the intense radiation. In the American water-cooled piles, the uranium rods were sheathed in aluminium to prevent corrosion and the escape of highly radioactive fission products into the coolant. To maintain a good thermal efficiency (25 per cent. to 30 per cent.) in the generation of electric power, the temperature of the uranium must be sufficiently high, but the use of aluminium sheathing limited the temperature to 300 deg. to 400 deg. C. In a "primary reactor," a large part of the non-fissile U238 could be transformed into fissile Pu239; and similarly, in a thorium slow-neutron reactor, with U235 or Pu239 as fuel, the destruction of the nuclear fuel could be offset more or less by the production of fissile U233 from Th 232. This re-cycling process strongly influenced the economic value of nuclear energy; because, while the world's annual heat-energy consumption corresponded to the consumption of no more than 170 tons of uranium or thorium, the pre-war annual production of uranium was only about 1,000 tons. By "breeding" nuclear fuel from U238 and Th232, however, nuclear energy could make a very large contribution to world power resources.

(To be continued.)

Electricity Supply in Scotland.—The North of Scotland Hydro-Electric Board published a distribution scheme for the islands of Seil, Luing and Easdale in the Firth of Lorne, on Friday, October 10. This scheme, which will provide a supply of electricity for the slate-quarrying industry of the islands, consists of transmission lines from Clachan Bridge to Toberonochy, with branches to Ardencaple House, Balvicar, Ellanbeich, Easdale and Cullipool. Power will be obtained from the Grampian Electricity Supply Company over lines crossing Clachan Sound and Cuan Sound.

THE INSTITUTE OF METALS; GLASGOW MEETING.

(*Concluded from page* 354.)

WE conclude our account of the recent annual autumn meeting of the Institute of Metals in Glasgow, by dealing below with the final proceedings at the last session of the meeting, held on Thursday, September 25.

CORROSION OF MAGNESIUM ALLOYS.

The last three papers considered were discussed jointly; all were taken as read to allow ample time for discussion. They were: "The Variation in Corrosion Properties Over Two Magnesium Alloy Sheets," by Mr. E. R. W. Jones and Mrs. Marion K. Petch, of the Metallurgy Division, Royal Aircraft Establishment; "The Corrosion of Some Magnesium-Base Alloys (High and Normal Purity) in Contact with Other Metals," by Dr. F. A. Fox and Mr. J. K. Davies, this being a record of work done in the laboratories of Magnesium Elektron, Limited; and "The Quantitative Implications of Hanawalt's Theory of Corrosion of Magnesium-Base Alloys," by Mr. C. J. Bushrod, of Messrs. George Angus and Company, Limited, and formerly of Magnesium Elektron, Limited.

In their paper, Mr. Jones and Mrs. Petch stated that as there had been some evidence that the susceptibility to corrosion of magnesium-alloy sheet to specification D.T.D. No. 118 (AM 503) varied over a sheet, they had carried out sea-water spray corrosion tests on chromated-treated specimens, selected at regular intervals from two large sheets of magnesium alloy, one to each of the specifications D.T.D. No. 118 and D.T.D. No. 120A (AZM), to discover any variation in corrodibility from part to part of the sheet. The results had shown that a fairly small random variation, probably due to the method of test, was observed on material to specification D.T.D. No. 120A. A large systematic variation occurred, however, in the material to specification D.T.D. No. 118, and it was found to be associated with a similar variation in the iron content of the material.

When an experiment had been appropriately designed, it was possible to isolate different sources of variation and to test whether or not the apparent differences could be due to experimental error. The methods used were those of R. A. Fisher in his work *Statistical Methods for Research Workers*. In the two series of tests carried out on rectangular specimens taken at regular intervals down and across the sheets, it was possible to isolate from the general variation, which was attributed to experimental error, the two components due to differences between horizontal rows and between vertical columns in the sheet. The results for the sheet to specification D.T.D. 120A indicated that the mean-square deviations attributed to rows and columns were small as compared with that due to error, and it could be stated, therefore, that the whole of the variation was due to error. The results for the sheet to specification D.T.D. 118 were rather different. It was found that the mean-square deviations for rows and columns were several times greater than that due to error. The degree of association between iron content and corrosion loss could also be measured, with the result that it could be said that the chance that the variation in corrosion properties was directly associated with the variation in iron content was more than 999 : 1.

In the second paper, Dr. F. A. Fox and Mr. J. K. Davies said that they had made a study of the corrosion of magnesium-base alloys—mainly those containing 5 per cent. aluminium of normal and high purity—immersed in 3 per cent. sodium-chloride solution saturated with magnesium hydroxide, while in electrical contact with other metals. The results had shown that, while the galvanic corrosion of many magnesium-base alloys was anodically controlled, the magnesium-aluminium alloys behaved differently. It was suggested that the surface anodic film was unstable and non-adherent and that the corrosion was controlled by cathodic reactions. Despite the advantage of a lower corroding potential, the alloys of normal purity corroded at a higher rate under conditions of galvanic attack than those of higher-purity alloy, owing, it was thought, to the greater number of local galvanic cells in the material of normal purity. The work had shown that, in general, the cast magnesium alloy containing 5 per cent. of aluminium behaved anodically to other metals when immersed in the corroding solution, exceptions being cast aluminium of high purity and some Elektron alloys.

In the third paper, on the quantitative implications of Hanawalt's theory of corrosion, Mr. C. J. Bushrod stated that, in their paper read in 1942 before the American Institute of Mining and Metallurgical Engineers, Hanawalt, Nelson and Peloubet had observed that magnesium and its alloys corroded at a roughly constant rate of 0·2 mg. per square centimetre per day (under specified conditions of alternate immersion in 3 per cent. sodium-chloride solution) unless certain elements were present in an amount exceeding a critical "tolerance limit." The most important elements in this class were stated to be nickel, iron, copper, cobalt, and silver, but only the first three had been subjected to close examination. In the present paper, the theory had been developed on a quantitative basis and the equation worked out had been found to agree with experimental results previously obtained, using two alloys of differing iron content. The extent of the agreement between the experimental results and the equations derived from the theory might be regarded as adequate support for the basic assumptions. More recent experimental work had shown, however, that alloys of this type, containing 0·002 per cent. of iron and less than 0·001 per cent. of nickel, corroded at rates which decreased with time. There were thus reasons for supposing that the basis theory was incorrect.

The discussion was opened by Dr. H. Sutton, who stated that, from the date of the experiments made by Mr. Jones and Mrs. Petch, it seemed probable that the sheet studied had been rolled from extruded stock. It was quite probable that sheet made by modern technique from cast stock would show very much less variation of iron content at the surface. A point of special interest was the correlation of iron content and corrosion resistance shown in the authors' experiments with the magnesium-manganese type of sheet. Fox and Bushrod, in earlier work, had found that iron-content variations were not by any means critical in this alloy, but their conditions of test had been very different. They, and also Hanawalt, Nelson and Peloubet, had employed immersion tests or alternating immersion tests very extensively and usefully, whereas Jones and Petch had used spraying tests, which, under suitable conditions, were highly informative. In the second paper before the meeting, the conditions of the tests carried out by Fox and Davies were very severe, and he would caution potential users of magnesium not to be too discouraged by some of the illustrations of corroded samples included in the paper. In the third contribution, Mr. Bushrod's curves certainly showed a very pleasing correspondence between his own observed results and the results calculated from his analysis.

Dr. F. A. Fox said that the paper by Mr. Davies and himself was written in a somewhat objective manner and he would like to summarise what he considered the moral to be. It seemed to be that, if the risk of galvanic corrosion was great and if that risk were likely to be decisive, the use of a high-purity magnesium alloy was not justified. If for various reasons the use of a high-purity magnesium alloy seemed to be justified, and if galvanic contacts were unavoidable, then, if these galvanic contacts consisted of aluminium alloys, the aluminium alloys should themselves be of high purity, otherwise the advantage of adopting high-purity magnesium was lost. If the galvanic contacts with the magnesium alloys were themselves magnesium alloys which were less noble than the alloy under consideration—for example, if Elektron AM 503 were coupled up with the 5 per cent. aluminium-magnesium-aluminium alloy M 5A, then the use of the high-purity M 5A would be justified.

In connection with the paper by Jones and Petch, it was to be noted that when the high-purity specifications had been brought out in the United States, no iron limits had been laid down for the magnesium-manganese alloy, and the work of Peloubet, on atmospheric-exposure tests, had also led to the conclusion that the influence of iron in the magnesium-manganese binary alloy was not of decisive, or even of noticeable, importance. His own work, under conditions of immersion, had pointed to the same answer. There were probably many other causes of variation in corrosion performance which might be of greater importance than the iron content. There could be, for example, local composition and impurity variations in nickel or in aluminium, or even in manganese. There could be a variation in superficial impurities, such as rolled-in dirt, or rolled-in aluminium, or even rolled-in iron particles on the surface, and there could be variations in the mechanical state, such as local differences in work-hardening or twinning.

Dr. Bruce Chalmers stated that Jones and Petch had investigated the scatter between results from the same sheet rather closely and certain results had been shown, by approved statistical methods, to be significant. In his opinion, the case was so clear that it could not be denied that under the conditions of test there was, in fact, a correlation between the iron content and the rate of corrosion. That did not suggest that this was the only factor and the paper had not implied that in any way. The next speaker, Dr. F. A. Champion, stated that the corrosion observed by Fox and Davies in the case of their aluminium samples was rather on the high side, since they had used 5 per cent. hydrochloric acid for cleaning their specimens after corrosion. This reagent did attack aluminium, and it seemed inevitable that some further loss had been incurred in this manner. He would recommend the use of concentrated nitric acid, preferably containing 5 per cent. of chromic acid, at a temperature not exceeding 30 deg. C., for cleaning specimens after corrosion testing. Mr. C. J. Bushrod, who spoke next, said that as far as he had been able to ascertain, the alloys tested by Jones and Petch were very insensitive to the presence of iron, and, as regards atmospheric tests, his laboratory was in agreement with the work of Peloubet.

Mr. J. K. Davies, referring to the paper by Jones and Petch, stated that probably the most important of the other factors controlling the corrosion qualities of Elektron AM503 had been noticed by the authors themselves in their X-ray work and micro-examination. They had found that the structure of the sheet had not completely recrystallised during the annealing treatment and that twin crystals remained. The authors had also observed that the specimens which corroded worst showed a greater number of twin crystals. In the case of the AM503 alloy, strained areas behaved cathodically to unworked or less strained areas. For example, when a specimen number was stamped upon a corrosion-test sample of Elektron AM503, no matter how severe the corrosion, the stamped number would always remain perfectly clear. On the other hand, in the case of aluminium-containing alloys, such as M5A, the stamped area was the first to be attacked in corrosion tests. The non-uniformity in the hardness of the sheet tested might possibly account entirely for the "scatter" in their corrosion-test results. Another factor was the possible variation in the number of free manganese particles from specimen to specimen. These were not removed by solution treatment and work done by Mr. Bushrod had shown that the distribution of the manganese played a very important part in the corrosion resistance of the AM 503 alloy, especially when a material, such as the authors', containing the relatively high percentage of manganese of 1·81, was under consideration.

After some comments on the mathematics of Mr. Bushrod's paper, by Mrs. M. K. Petch and Mr. E. R. W. Jones, the President closed the discussion, and asked the authors to reply in writing. He then proposed a vote of thanks to all who had contributed to the success of the Glasgow meeting. After a luncheon given by the Scottish local section of the Institute at the Grand Hotel, the members left by motor coaches to visit the works of Albion Motors, Limited, Scotstoun; Babcock and Wilcox, Limited, Renfrew; and Barr and Stroud, Limited, Anniesland. A dinner and dance were held in the evening at the Grosvenor Restaurant, and the whole of Friday, September 26, was devoted to an excursion on Loch Lomond.

AUTOMATIC TRAIN CONTROL ON THE GREAT WESTERN RAILWAY.

THE Great Western Railway Company have recently designed a modified form of automatic train-control and audible cab-signal apparatus, to render it suitable for use on lines equipped with four-aspect colour-light signalling. Audible cab-signal apparatus has been used on the G.W.R. since 1906, and it was fully described by Mr. (now Sir) William Stanier, in a paper read before the Institution of Mechanical Engineers on December 18, 1914 (see ENGINEERING, vol. 98, pages 42, 748, 770 (1914)). It has long since passed the experimental stage on the Company's system, on which 2,462 ramps are now in use, and 3,364 locomotives are equipped.

Certain other railways in this country, however, are now using four-aspect colour-light signalling, and it has been contended that the G.W.R. audible-signal, automatic train-control apparatus could not be used with this system. The company have, therefore, developed the apparatus for this purpose, although they have not yet installed any four-aspect signalling. The four colour-lights, which are mounted on a single standard, can display three different indications, when used as a distant signal, thus: green, indicating the signal ahead is at the "line-clear" position; double yellow, indicating "caution"—"the second signal ahead is at danger"; and single yellow, indicating "caution"—"the first signal ahead is at danger." The first and last of these indications correspond to the "line-clear" and "caution" signals of the semaphore system, and the same bell or siren signal is heard in the cab. The double-yellow "caution" signal, however, is now indicated in the cab by a horn, followed immediately by the siren—the horn being the additional apparatus. This audible signal is achieved by using a current in the ramp of opposite polarity to that used for the "line-clear" signal; being of opposite polarity, it is unable to take over the operation of the air-valve electromagnets from the locomotive battery, which has been cut off by the vertical movement of the shoe, so that the horn and siren sound, and the brakes are applied. The horn can only be switched on by current of this polarity.

The Company invited the railway inspecting officers of the Ministry of Transport, and representatives of the other main-line railways and the Press, to attend a demonstration of the modified apparatus on Sunday, October 12, 1947, on a special train, consisting of a 4-6-0 locomotive, the Earl of Powis, No. 5056; a dynamometer-car; two vestibule coaches; and a coach fitted with a demonstration apparatus, which was used for explanatory purposes at the end of the run. The tare weight of the train, without the locomotive, was 133 tons. The locomotive was equipped with the modified form of apparatus, and the audible signals in the cab were relayed to loudspeakers temporarily installed in the coaches.

The train ran from Reading to Paddington, and on the first part of the journey, as far as Maidenhead, a distance of about 12 miles, the "line-clear" (bell) and "caution" (double-yellow, horn-siren) signals were demonstrated. On this section, eight ramps were passed, and the company had arranged for the train to accelerate as far as the eighth ramp, within about 1½ miles of Maidenhead station, to approximately the highest speed permitted on the G.W.R. at the present time, *i.e.*, 92 to 94 miles an hour. The first ramp, a little over a mile from Reading, was passed at 61·0 miles an hour, and a "line-clear" (bell) signal was received. A similar signal was received at the second ramp, which was passed at 67·5 miles an hour. At the third ramp (75·0 miles an hour), there was an unrehearsed and unexpected demonstration of a typical "safe" failure of the apparatus. The semaphore signal was set at "line-clear," but a siren ("caution") signal was heard; on such occasions, of course, the driver can cancel the signal.

The fourth ramp demonstrated the "caution" (double-yellow, horn-siren) signal. Although, as already explained, the Company are not yet using four-aspect colour-light signalling, the fourth, sixth, and eighth ramps were specially wired to simulate the double-yellow signal of such a system, for the purpose of this demonstration. The driver cancelled the "caution" signals at the fourth (79·5 miles an hour) and sixth (90·5 miles an hour) ramps, received the "line-clear" (bell) signal at the fifth (83·5 miles an hour) and seventh (93·4 miles an hour) ramps, and passed the eighth ramp at 96·4 miles an hour, where he received the double-yellow signal and applied the brakes, to bring the train to a stand at Maidenhead station. The journey was continued to Paddington, and, at Farnham Road signal-box, the automatic train-control apparatus was allowed to operate as though the driver and fireman were ignoring the signal. The train was travelling at 63·6 miles an hour, with the locomotive regulator fully open, when the brakes were applied automatically, and the train was brought to rest in 1,505 yards.

LABOUR NOTES.

THE Amalgamated Society of Woodworkers has rejected by 39,350 votes to 20,954 the proposal on the subject of wages made by the Minister of Labour and National Service to the National Federation of Building Trades Operatives, of which the woodworkers' organisation is a unit. The original claims of the unions was for increases of 6*d.* an hour for craftsmen and 9*d.* an hour for labourers. Mr. Isaacs's offer was an increase of 3*d.* an hour on the basic rate and a bonus scheme which was calculated to increase weekly wages by, at least, 20 per cent. Most of the other unions affiliated to the National Federation have, it is understood, accepted the Minister's offer. If, as is assumed, the aggregate vote is to decide the issue, only formal meetings with the Ministry and the employers seem to be necessary to bring the new arrangement into operation.

In the industries covered by the statistics regularly compiled by the Ministry of Labour and National Service, the changes in rates of wages reported to have come into operation in the United Kingdom during August resulted in an aggregate increase estimated at approximately 340,000*l.* in the weekly full-time wages of about 840,000 workpeople. In addition, a number of workpeople had their hourly rates increased in conjunction with a reduction in normal weekly hours of work. The great majority of the workpeople whose wage rates were increased in August were agricultural employees in England and Wales.

During the eight months, January to August of the present year, 2,612,000 workpeople received increases of weekly wage rates amounting to 831,800*l.*; in the corresponding period of 1946, 4,700,000 workpeople received increases amounting to 2,350,000*l.* In the metal, engineering, and shipbuilding industries, 130,500 workpeople received weekly wage-rate increases totalling 41,000*l.* during the 1947 period; in the gas, water and electricity supply services, 152,000 workpeople received increases of 28,500*l.*; in transport services, 452,000 workpeople received increases of 1,600,800*l.*; and in public administrative services, 327,000 workpeople received increases of 78,300*l.*

The changes in hours of labour reported to have come into operation in August resulted in an average reduction of about 3½ hours a week for about 250,000 workpeople. The principal industries and services affected were civil-engineering construction, in which the normal working week beyond which overtime rates become payable, was reduced from 48 (averaged over the year) to 44 hours throughout the year; certain branches of the leather industry, in which the normal working week was reduced from 48 to 45 hours; the London Passenger Transport Board railway services, in which the standard working week was reduced from 48 to 44 hours; the cutlery industry, in which the normal weekly hours of work beyond which overtime rates become payable were reduced from 48 to 44; the asbestos-cement industry, in which the normal weekly working hours were reduced from 48 to 45, or from 47 to 44, according to district; and the freight and passenger sections of the Northern Ireland Transport Board, in which the normal working week of employees other than horse carters was reduced from 48 to 44 hours.

In the eight months, January to August, of this year, changes in hours of labour in the industries covered by the statistics compiled by the Ministry of Labour and National Service, resulted in an average reduction of about 3½ hours a week for about 4½ million workpeople.

Official figures indicate that the number of industrial disputes leading to stoppages of work in August, in the United Kingdom, was 112. In addition, 11 stoppages which had begun before August were still in progress at the beginning of that month. The approximate number of persons involved during August in these 123 stoppages, including people thrown out of employment at the establishments concerned, though not themselves parties to the disputes, was nearly 47,000; the aggregate number of working days lost through these stoppages in August was about 122,000. Of the stoppages known to have been in progress—in August, the coal-mining industry accounted for 70, involving over 29,000 persons and resulting in an aggregate loss of nearly 80,000 working days.

Of the 112 disputes leading to stoppages of work which began in August, 19, directly involving 7,500 persons, arose out of demands for advances in wages; 44, directly involving 9,000 persons, arose out of other wage questions; 5, directly involving 1,700 persons, arose out of questions relating to working hours; 14, directly involving 3,100 operatives, arose out of questions respecting the employment of particular classes or persons; 26, directly involving 3,800 persons, arose out of other questions relating to working arrangements; and 3, directly involving 400 persons, arose out of questions of trade-union principles. One stoppage, directly involving 14,900 persons, was in support of workpeople involved in another dispute.

On the recommendation of the executive committee, a delegate conference of the National Union of Mineworkers—which sat on Friday last week—accepted the agreement on the subject of increased working hours reached by the negotiating committee of the union and the National Coal Board. The agreement embodies the principle that overtime will be voluntary, and it is left to each district to decide whether half an hour should be added to each normal week-day shift, or an extra shift be worked on Saturdays. Overtime is to be worked within the framework of the Five-Day Week Agreement, and it will not be compulsory to enable a miner to qualify for the existing bonus. An undertaking has been given, however, by the union's executive that, while overtime will be voluntary, a substantial amount will be worked regularly.

The delegates will go back to their districts and explain the terms of the agreement to members, and, if the rank and file approve, the working of the extra time will begin in the first week in November. The conference, it is understood, instructed the executive to go ahead with the application to the National Coal Board for an increase of 1*l.* a week in minimum wage rates and corresponding increases in piece-work prices.

Messrs. The Renold and Coventry Chain Company, Limited, announce that a sum of 45,100*l.* is available for distribution among their 4,200 employees in Manchester, Coventry and Cardiff under their profit-sharing scheme. The share of each weekly and hourly-rated employee will be equal to approximately two weeks' wages.

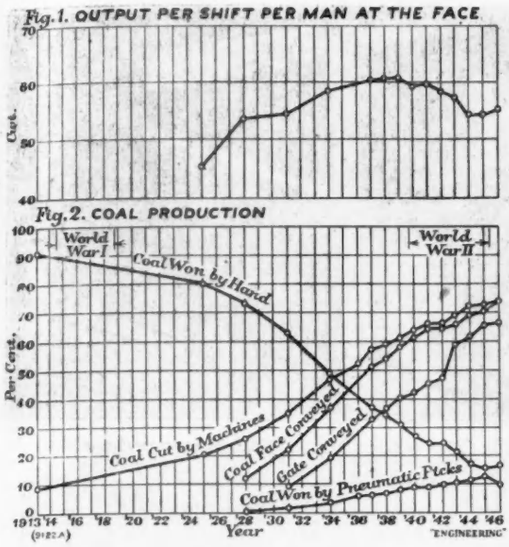
Under an agreement reached by the Association of Supervisory Staffs, Executives, and Technicians and the Affiliation of Textile Officials' Association, nearly 2,000 managers and overlookers employed in Lancashire mills become members of the former body. The Affiliation is a federation of overlookers' associations which has existed in Ashton-under-Lyne, Bolton, Rochdale and Stockport for upwards of 40 years.

Speaking at a luncheon of the Institution of Works' Managers, in London last week, Lord Woolton suggested that employees should be paid on results and management given additional payments based on profits. He would like, he said, to see all operatives in industry paid on the result of their production, and all ranks of management given supplementary payments based on the profits they made out of their industries. In that way it would be possible, he believed, to produce goods that sold economically. "We were told, without ceasing," he declared, "that what we had to do was to export. That was not true; we had to sell the goods that we exported, and that might be a very difficult thing. The best way to get customers was by producing at a rather lower price than your competitor."

According to the *Review* of the International Labour Office, domestic employees in France are now paid a minimum wage. The employees are divided into two categories—those paid by the hour, and those paid by the month, the latter group being sub-divided into 11 occupational classifications. The basic wage is paid to household workers with less than one year's experience, and to page boys and caretakers in private homes. The highest wage, 90 per cent. above the minimum, is paid to chefs, housekeepers, companions, and butlers in a supervisory capacity. A sliding scale is set for persons under 18 years, those over 18 being regarded as adults. Lower wages may be paid to persons, whose work through physical disability is inferior to that of other persons of the same occupational category. Payment in kind, including food and lodging, is deductible from wages, its value being fixed by legislation.

In an amended Shipping and Seamen Act, the New Zealand Government has fixed the hours of work of seafarers at 40 a week. The measure applies to all seafarers whose employment is governed by an agreement with the crew made in New Zealand, or who are employed in a vessel of less than 25 registered tons engaged exclusively in coastal trade. Overtime may be worked if the master of the vessel deems it necessary, but this must be compensated for by pay at a higher rate or by means of time off with pay.

MECHANISATION OF COLLIERIES.



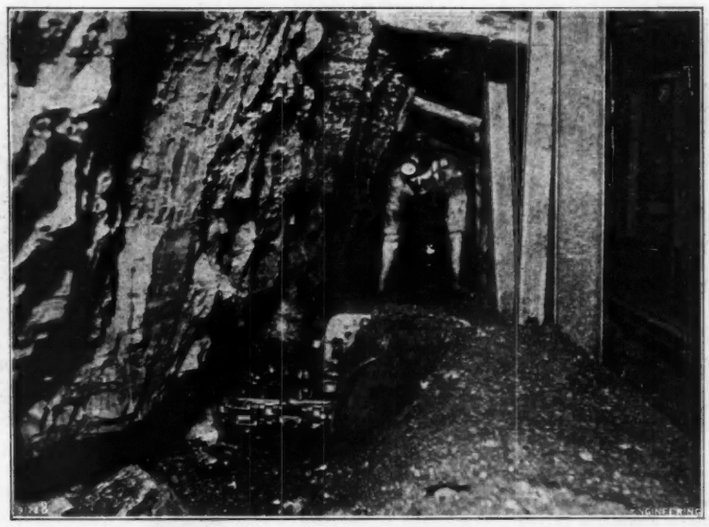


FIG. 3. COAL-CUTTING MACHINE WITH "GUMMER".

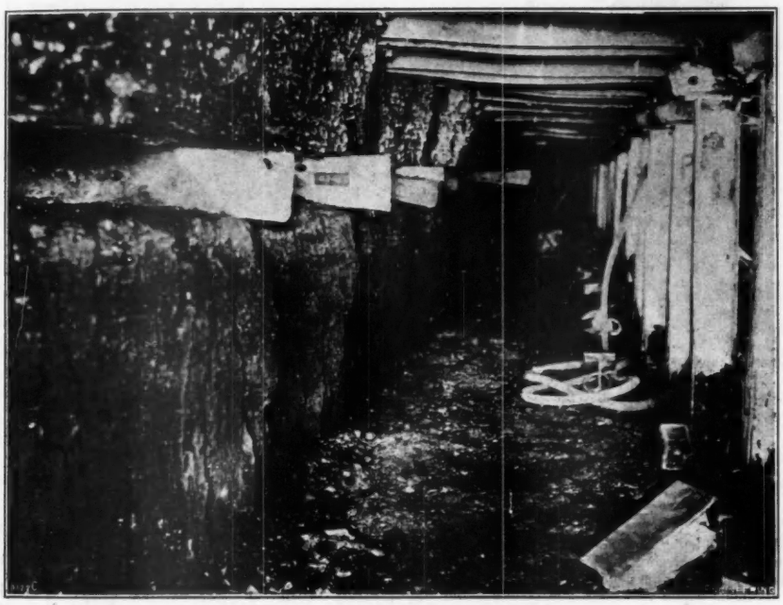


FIG. 4. LONGWALL FACE WITH HOLING CUT.

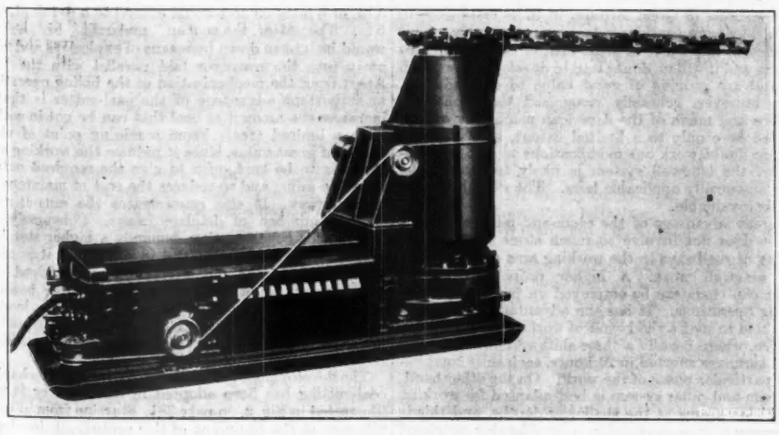


FIG. 5. COAL-CUTTING MACHINE WITH HYDRAULICALLY-OPERATED OVERCUTTER.

THE MECHANISATION OF COLLIERIES.*

By FORREST S. ANDERSON.

To those not associated with the mining industry, the term mechanisation, as applied to collieries, usually suggests the mechanisation of the actual coal-getting operations. This is certainly the phase which has been most widely publicised, but it is well to realise that such other phases of the work as underground transport and tub handling, for example, also require the greatest consideration. In fact, unless they are brought into line, the full advantage of coal-face mechanisation cannot be realised. This inter-dependence of all phases of mining work brings its own problems, especially under conditions, such as we have in Britain, where the coalfields have been developed for many years and many working faces are a long way from the mine shafts. The adoption of new methods usually involves heavy development charges in several directions and the remaining life of the colliery, or a particular section of it, may not warrant the expenditure.

Mining inevitably entails long-term planning and so, as a rule, the fruits of any new method or scheme are not produced quickly. It must also be appreciated that no standardised scheme can be applied and, whatever may be done along broad general lines, there must always be modification and adaptation to meet individual geological conditions. Beyond that, there lies the unknown and the unexpected which are encountered in the course of exploitation and which certainly lend variety to the mining engineer's work. The scope for discussion of mechanisation of collieries is so great that in a single paper it must be restricted, and I have been asked to deal particularly with coal-cutting machinery. In doing so, I propose to interpret the term in a liberal way so that I may discuss actually the mechanisation of the coal-getting operations. While mechanical coal-cutting is the basis on which these operations are founded, it is a practice which has been fairly well established for many years. Great developments are now taking place in extending this mechanisation to the loading of the coal at the coal face, and I will take the opportunity to give some outline of the work that is being done in this direction. As I understand that many to whom my remarks will be addressed have no particular experience in, or knowledge of, either mining methods or machinery, I will deal only with the broad aspects of the subject and with special reference to what is being done in this country.

The problem that arises in the mechanisation of coal getting is to find a way whereby the coal may be broken out from the seam and filled away with the minimum demands on human labour, while, at the same time, keeping the working places safe for continuous day by day operation. A solution is particularly urgent to-day, because of the shortage of labour, in the first place, and also because of the necessity of eliminating as much as possible of the laborious and monotonous toil from the miner's work, so that the calling may become more attractive and interesting. The solution of the

* Paper read before Section G of the British Association, at Dundee, on September 2, 1947.

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Fig. 6 Shortwall Coal Cutter at Work.

Fig. 8. Arc Shearer Holing Near Middle of Seam.

problem, however, involves not only the provision of suitable machines, but also the adoption of suitable mining methods. The methods of mining, in fact, have not changed in principle for many years, although many variations and adaptations have been developed. The two basic methods are known as the longwall system and the room-and-pillar system, and I will give a brief explanation of these as a background to our further discussion.

In the longwall system of mining a coal face is opened up in a straight line extending for, say, 100 or 200 yards. This face of coal is then worked forward by removing successive slices, making perhaps a 5 ft. advance each time. Roadways, which are at right angles to the face line, have to be kept open up to the face to allow for ventilation and the passage of men, coal and supplies. This is done by taking down some of the strata as the face advances and packing it into the space left by the removal of the coal. In this way is formed a tunnel or roadway, say, 12 ft. wide by 6 ft. or 8 ft. high, and sufficient of these are made at intervals along the face, as circumstances may demand. In addition to the roadways, it is necessary to keep a passage open in front of the coal face for its full length. This is only the height of the seam being worked, and is supported by two or three rows of props parallel with the face, the rows and individual props being spaced at suitable intervals.

It is in this passage along the coal face that the men and machines engaged in coal getting are employed. Usually it is about 8 ft. or 9 ft. wide, and there is an alley between the first row of props and the coal face along which the coal-cutting machine can travel. In the alley between the first and second row of props, there is usually placed a conveyor into which the coal is filled after being broken out from the seam. This face conveyor then carries the coal to the roadway at one end of the face and discharges into a roadway conveyor which is located there. At a suitable point, the roadway conveyor will discharge into the tubs or mine wagons in which the coal will be transported to the shaft.

In room-and-pillar working the seam is exploited by driving a series of rooms or runnels in straight lines and at right angles to each other in the seam itself, so as to leave a succession of square or rectangular pillars of coal. The rooms may be 5 yards wide and the pillars 20 or 30 yards square, but naturally these sizes vary greatly according to conditions. Usually the concession is split up by driving out main haulage roads and then subdividing the area into a series of panels adjacent to these haulage roads. Each panel is then slit up into pillars by the driving of rooms and immediately afterwards the pillars are worked out. Much of the success of this method of working depends on the speed with which the rooms can be driven and the plan on which the pillars are extracted.

In early British mining practice, the room-and-pillar system of working was widely adopted, but to-day the longwall system is by far the more generally employed. This has been influenced to a great extent, no doubt, by the necessity of working thinner seams and seams at considerable depths. Consequently, the machinery developed in Britain has been largely for longwall use, although there have been developed also machines for room-and-pillar mining. In America, on the other hand, the room-and-pillar system is employed almost exclusively, probably because large virgin areas in relatively thick seams and at comparatively shallow depths are still being worked. The American operators, however, have developed the technique of room and pillar working to a high degree, and introduced mechanised methods which give very fine results under their conditions. During the war, under the pressure of our necessity, a concentrated effort was made to introduce the American mechanised methods of room-and-pillar working in Great Britain, in those conditions in which they were considered to be most suitable. This stimulation has led to a great deal of research in this country and it will no doubt lead to developments which will and are proving of great value to our industry. It is, however, generally recognised that American practice and much of the American machinery can be adopted here only to a limited extent, and while we shall no doubt work out modifications to suit our conditions, the longwall system is likely to remain the more universally applicable here. The stimulus, however, is invaluable.

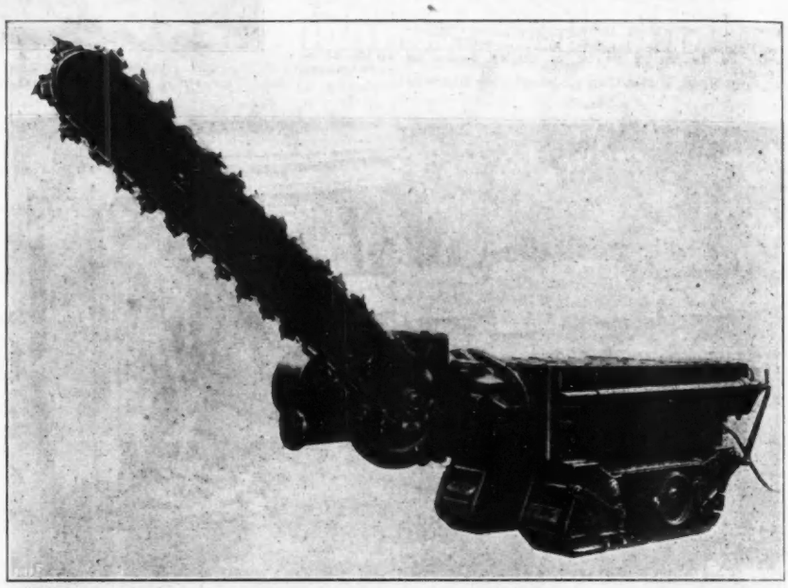

Fig. 7. "Dreadnought" Universal Arc Shearer.

A great advantage of the room-and-pillar system is that it does not involve so much stone work in the making of roadways in the working area as is required with longwall work. A higher proportion of the labour can therefore be employed on productive coal-getting operations. It has the advantage also that it is not tied to such a rigid cycle of working as in longwall practice, where usually a three-shift system is adopted and a turnover effected in 24 hours, each shift completing a particular phase of the work. On the other hand, the room-and-pillar system is best adapted for working the thicker seams at the shallower depths, and this is one reason why its application is considerably restricted in Great Britain.

In the mechanisation of coal-getting operations, the function of the coal-cutter is to make an incision to a limited depth in the seam so that the coal may be readily broken out and so filled away. A common practice, for example, on a longwall face, is to make a holing cut in the coal next to the floor of the seam along the whole length of the face. This cut would be 5 in. or 6 in. wide and would extend to a depth of, say, 5 ft. Thereafter, the coal so "undercut" or "holed" would be broken down by means of explosives and filled away into the conveyor laid parallel with the face. Apart from the mechanisation of the holing operation, an important advantage of the coal-cutter is that it increases the amount of coal that can be got in a shift from a limited area. From a mining point of view, this is of great value, since it reduces the working area that has to be kept open to give the required output from the mine, and so reduces the cost of maintenance of roadways. It also concentrates the output to a smaller number of haulage ways. Conversely, of course, this concentration demands a higher standard of haulage arrangements and in old mines it is often difficult to get the full advantage of improved performance at the working face. This factor becomes even more pronounced when mechanical loading methods are introduced. The problem of haulage underground is therefore one of the features which is receiving a great deal of study at present.

The development and the extent to which mechanical coal-cutting has been adopted in this country is well illustrated in Fig. 2, on page 381. Starting from practically zero at the beginning of this century, it developed slowly at first but later at a steadily increasing rate until

MECHANISATION OF COLLIERIES.

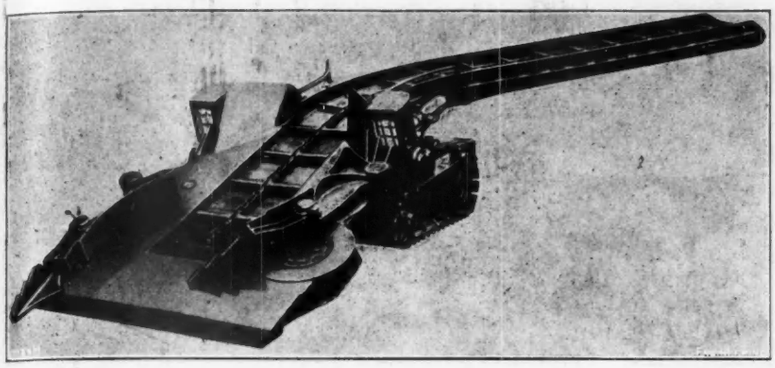

Fig. 9. M. & C. Mobile Loader.

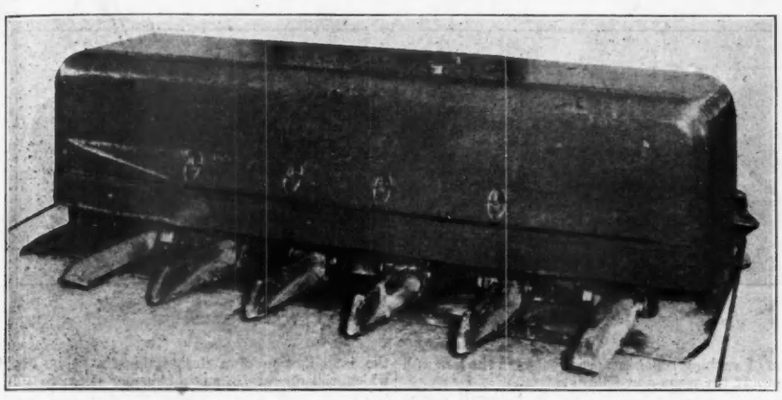

Fig. 10. Huwood Power Loader.

over 70 per cent. of the coal mined in this country to-day is machine cut. From this diagram also it may be noted that, in the last 20 years, there has been a slow but steady increase in the amount of coal won by pneumatic picks. As some of you may be aware, the pneumatic pick is very extensively used for coal production in Germany and, in fact, on the Continent as a whole. It is generally agreed, however, that its application here as a primary coal getter is limited due to the great difference in characteristics between, say, the Ruhr coal and British coal.

The development of coal-face conveying and gate conveying, the second phase of coal-face mechanisation, is also illustrated in Fig. 2, and it may be noted that, although introduced at a later date than coal-cutting, over 70 per cent. of the coal mined is now conveyed at the face. While it may be stimulating to record such progress in face mechanisation, the real test of its merit is in terms of cost of output. This, of course, brings in many variables, but the output per man at the face over the last 20 years may be seen by reference to Fig. 1, page 381. It may be noted that right up to 1939 there was a steady improvement in output, but since then there has been a steady decline until 1944 when the drop was arrested, and in 1946 the graph took an upward turn again. I will not try to explain the vagaries of this graph, but I think that, as a measure of the effect of mechanisation, the troubled war years must be discounted.

Time will not permit of any excursion into the history of coal cutting, interesting though it is, but I would mention that there is a record of a patent for mechanical coal cutting which was taken out about 1760. To-day, the design of the coal-cutter is almost entirely stabilised with the chain-type machine, and this applies whether it be employed for longwall work or room-and-pillar work. There areh, owever, many forms of this type specially adapted for particular duties, and I now propose to give a brief description of the principle of these and how they function.

The longwall chain coal-cutter is the simplest and also is employed in the greatest numbers in this country. It is approximately 8 ft. long by 2 ft. to 2 ft. 6 in. wide, and may be anything from 12 in. to 18 in. high. It consists essentially of a motor, rated at from 40 to 60 h.p., dependent on the size of the machine, with a gearhead mounted at one end and a rope haulage unit at the other end. On the gearhead is mounted a jib bracket which can be rotated in a horizontal plane through approximately 180 deg. This jib bracket supports the jib, which projects out from the machine, the jib forming the race for a special endless chain which incorporates holders for the picks which cut the coal. This chain is driven at a speed of 400 ft. to 500 ft. per minute, through the gearing in the gearhead. When in operation, the jib projects at right angles to the machine and the provision for swinging the jib bracket is to allow the machine to work in either direction. The haulage unit incorporates a rope drum which is arranged to be driven at a suitable speed for the machine when cutting, say, anything from 12 in. to 5 ft. per minute, and also a flitting speed of 30 ft. or 40 ft. per minute which is used when moving the machine about at the face. The coal-cutter rests directly on the floor of the seam and, in the simple longwall machine being described, the cutting chain is arranged to work at floor level.

The method of operation is to introduce the jib into the coal at one end of the face, and then, by anchoring the haulage rope along the face, the haulage unit pulls the machine along, thereby making an incision in the coal seam at floor level. The cutting chain acts also as a conveyor and brings out the holings or cuttings which are made. These are removed on modern machines by a mechanical "gummer," which discharges the holings clear of the cutting chain (see Fig. 3, page 381). One form of gummer consists of a screw into which the holings are thrown by the action of the chain at the driving sprocket, and this screw then worms the holings back behind the machine. It is not always desirable that the holing cut should be made at floor level and, consequently, overcutters have been designed to cut in the middle of the seam (see Fig. 4, page 381), or even at roof level.

The problem of cutting at roof level brings a number of difficulties which have been overcome by designing a machine with a turret to carry the jib at the gearhead end, the turret being arranged so that it can be elevated or lowered as required, by hydraulic means. Such a machine is illustrated in Fig. 5, on page 381. For room-and-pillar working, two principal forms of the chain machine are employed—the shortwall coal-cutter and the arc-shearer. The shortwall machine, Fig. 6, opposite, is the simpler form, and is the equivalent of the longwall machine, with modifications to suit its application for undercutting rooms, which may be anything from 12 ft. to 30 ft. wide. It requires greater manœuvrability than the longwall machine and, consequently, is usually provided with two rope drums which are controlled independently by friction clutches. In physical dimensions it is shorter and broader, and, finally, there is no provision, as on longwall coal-cutters, for swinging the jib, which is permanently mounted in line with the machine.

The method of operation is to sump into the coal at one side of the room, using the two haulage ropes for this purpose, and then to pull the machine broadside across the place, thereby making the holing cut at floor level. The result, therefore, is similar to what is obtained in longwall work. In some cases, the shortwall machine remains permanently in the one room, and is driven forward intensively, making anything from three to five cuts in a shift. In other cases, a special flitting truck is provided to move it round the working area, to cut a series of rooms in succession. The time taken to cut a room is frequently from 15 to 20 minutes.

It may be interesting to note that the shortwall machine is to America what the longwall machine is to Britain, and, until a few years ago, there was no market for it in this country which would warrant its manufacture here. During the war, a demand did arise owing to the adoption of intensive mechanised methods of room-and-pillar working in this country, and a shortwall machine of British design and manufacture is now available and is being widely used.

The arc-shearer is a rather more complicated machine, and works on a different principle of application from those already described. It is designed to make a holing cut at any height on the face, and arranged also to make shearing or vertical cuts at suitable points, with the object of giving further assistance in the preparation of the coal for loading. It incorporates also its own flitting carriage so that it is highly mobile and may move about from one room to another under its own power. It may be considered, in the first place, as a development of the simple arcwall machine which, in turn, was a development from the longwall machine.

On the arcwall machine, the jib is mounted on a jib bracket which can be rotated as on the longwall machine, but special provision is made for a convenient power drive to the jib bracket. In operation, the machine is driven into the centre of the room or heading under its own tractive effort, with the jib slewed back to one side, until the gearhead is up against the coal. The jib bracket is then rotated, and so a holing cut is made in the coal in the form of an arc. With the simple arcwall machine, it is not usual to make the holing cut at floor level, but as it is generally employed only in the thicker seams, this is quite convenient.

The arc-shearer, Fig. 7, opposite, on the other hand, has additional provision whereby the position of the jib may be adjusted to a higher or lower level, as required. In one design, this adjustment is obtained by arranging the gearhead in two sections, each of which may be rotated on a longitudinal axis, but with the axis of the jib head, which actually carries the jib, eccentric with the main head. The main head may therefore be considered as the web of a crank, with the jib head mounted on the crankpin. Both heads have a full rotational movement, which is power-driven and under complete control. This design, therefore, permits the cutting jib to be brought into a vertical plane in order to make a shearing cut, as shown in Fig. 8, opposite, in addition to the adjustment in the height of the cutting position. The power-driven carriage, which gives mobility to the machine, may be on wheels, tractors or rubber tyres, as circumstances may demand. The arc-shearer has been developed and employed for many years, both in this country and America, but as might be expected, the American machines are usually much bigger in physical dimensions than the British machines and are designed to operate in wider rooms than are normally practicable in this country.

Approximately 70 per cent. of the coal-cutting machines in Great Britain are powered by electric motors, and of these by far the greater number are of the squirrel-cage type. It is interesting to note that, while direct current is used to only a limited and diminishing extent for coal-face work in this country, it is almost universally employed in American mines. The reason for this is probably bound up with the extensive use made of direct current for trolley-type electric locomotive haulage underground. Compressed air is still used here for face work, particularly in specially gassy mines, but the proportion of air-driven machines to electric machines is steadily diminishing.

In the design of coal-cutting machinery, the two factors which are of outstanding importance, particularly for this country, are strength and minimum physical dimensions. The duty which it has to do calls for high power, and the conditions under which it works demand great strength to withstand crushing, due to falls of coal and rock, in addition to much abuse in operation, to which it is frequently subjected. On the other hand, the necessity for providing adequate support to the roof, and the limited height in which the

machines are frequently required to work, mean that the physical dimensions must be kept as low as possible. Added to this are the factors that they are working in a dusty atmosphere and must be totally enclosed, and the electric motors must be of flameproof construction on account of the prevalence of gas, which can be readily ignited at certain concentrations. The success with which these limitations have been met is well exemplified in the design of a longwall machine for thin seams, where a 40-h.p. machine has been provided which is only 12 in. high by 26 in. wide by 7 ft. 10 in. long. This is certainly taking an extreme case, but it does make clear that, in the design of coal-face machinery, a very specialised knowledge is required of all the conditions of application, so that particular dimensions may be increased or limited according to the nature of the work of each machine.

We may now consider briefly the further aspect of mechanical coal getting to which I have referred, namely, power loading. In this sphere the Americans have done a great deal, and approximately 50 per cent. of the American output is now power loaded. Their developments, however, have been almost entirely limited to the room-and-pillar system of mining, and, as already explained, the longwall system is the more commonly employed here. Nevertheless, their methods have found many useful applications in this country, and particularly in areas where only a limited extraction of the coal is permitted. In these conditions, rooms may be driven successfully to extract, say, 40 per cent. to 50 per cent. of the coal, while the more difficult operation of extracting the pillars has not to be undertaken.

Two main types of loading machines are employed in America and have been introduced here: the Duckbill loader and the mobile loader. The Duckbill loader is essentially a shaker conveyor with a special loading pan, which is mounted at the face end of the main conveyor, and may be advanced or retracted by the action of friction grips on the end trough of the main conveyor. After the coal in the room or heading has been shot down, the Duckbill head is fed into the loose coal, which is carried away by the action of the shaker conveyor. This machine is widely used in orthodox room-and-pillar working in conjunction with a shortwall coal-cutter, and is also very suitable for the driving of single headings for development work.

The mobile loader, as its name implies, is capable of movement under its own power, usually by means of a tractor set, and is a self-contained loader unit. A typical example, illustrated in Fig. 9, on page 383, incorporates an elevating chain conveyor with a wide platform at its lower end. On this sloping platform are mounted two arms which are given a gathering motion. When the loader is fed into the loose coal, the gathering arms collect the coal and feed to the elevating conveyor which, in turn, delivers at a point behind the loader, either into a tub, a fixed conveyor, or a shuttle car. These mobile loaders are very efficient, with a high loading capacity and, where conditions are well suited to their use, have given outstanding results.

The shuttle car to which I have referred is really an electrically-driven truck with rubber tyres and is designed specifically for duty in the mine. Each shuttle car will carry about 3 tons of coal and is employed to transport the coal between the loader and a centrally-located conveyor which will ultimately deliver the coal into the tubs or mine cars. The most notable developments in longwall power loading have taken place in this country and, although work in this sphere has been going on for a long time, it has only been during the war years that it has been brought to fruition. The problem of preparing the coal for loading has presented greater difficulties on longwall faces than in rooms, but success has been achieved, both with the simple loader and with the cutter loader.

The simple loader may be exemplified in the Huwood type which is employed to transfer the coal, after it has been undercut and blown down, on to the face conveyor, which is laid parallel with the face in the orthodox manner. The loader, shown in Fig. 10, page 383, consists essentially of a series of parallel loading arms, about 18 in. long, which are mounted on a bar, about 5 ft. long, and project forward from it. This carrying bar is actuated by an eccentric at each end and gives the loading arms a rotational movement in a horizontal plane. The loading arms operate at floor level and, on the back part of the stroke, are masked by the breastplate of the loader. The loader starts at one end of the face and is hauled forward by its own haulage mechanism which forces the loading arms into the prepared coal. The action of the loading arms helps to break up the coal and also carries it over to the face conveyor which is lying alongside. It will be understood that, if the coal has not been sufficiently broken up, or if it is not fractured at the back of the cut in such a way as to leave a straight face line, considerable difficulties in loading will be encountered. Several of these machines are now at work successfully, and it is particularly interesting to note developments in their application in the thinner seams employing a system of working which is a cross between the longwall system and the room-and-pillar system.

MECHANISATION OF COLLIERIES.

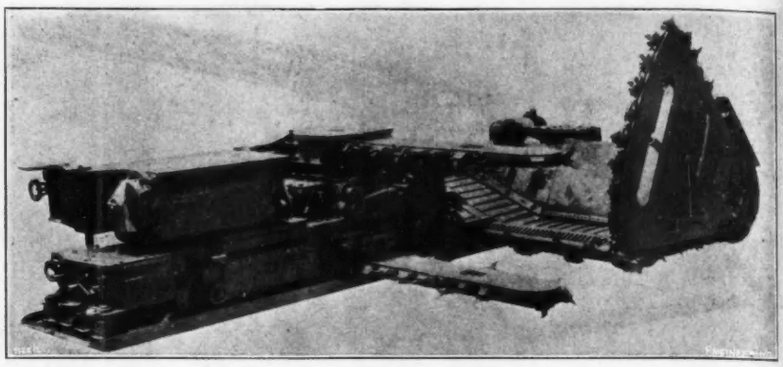

Fig. 11. Meco-Moore Cutter Loader.

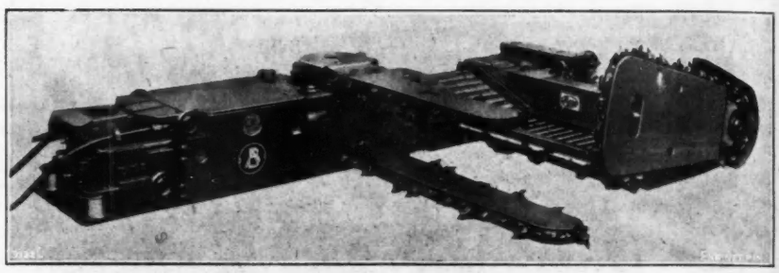

Fig. 12. Meco-Moore Low-Type Cutter Loader.

The most notable development in longwall power loading is the A.B. Meco-Moore cutter loader which has been much publicised in the popular Press recently. It was invented by Mr. M. S. Moore, who has recently died, and is illustrated in Fig. 11. In the early days of the war it was sponsored by the Mechanisation Advisory Committee of the Ministry of Fuel and Power, and, with their assistance and the combined efforts of a colliery company and the manufacturers, there was developed a new machine which has achieved outstanding success. The principle of this machine is that it combines a coal-cutter and a loader in one machine, which operates in such a way that the coal is prepared for loading and filled on to the face conveyor in the one combined operation.

The cutter unit is very similar to the usual longwall coal-cutter, except that it has two cutting jibs, one operating at floor level and the other at some intermediate position, usually located about the middle of the seam. Attached to the rear of this cutter unit is the loader. This consists essentially of a transverse armoured conveyor belt which is arranged to receive the coal, elevate it, and discharge it on to the face conveyor. On the leading edge of the loader is a loading bar which is fitted with special picks arranged so that, as the bar rotates, they help to break up the coal and feed it on to the loader belt. At the back of the loader is mounted a shearing jib, which is parallel with the line of face, and shears the seam from roof to floor at the back of the cut made by the horizontal cutting jibs. The machine is hauled along the face by its own haulage, as previously described for a longwall coal-cutter, and, as it travels, the pressure of the roof crushes and breaks down the coal. Much ingenuity and experiment were necessary before the desired results were obtained. The essence of success ultimately lies in the advantage that is taken of natural features in the coal, and the inducement of fractures by taking suitable advantage of roof pressure. Even where some of the seam characteristics that are desirable for this class of work are absent, success has been obtained by the expenditure of additional work, and great credit is due to those colliery companies who, by their initiative and perseverance, have extended the scope of the cutter loader.

Its sphere of application, of course, is limited at present by natural mining conditions and, particularly, by seam thickness. The first design was deliberately arranged for seams over 4 ft. thick, since it was from these that the greatest coal output per machine could be looked for. The field has now been extended by the introduction of a design, illustrated in Fig. 12, which will operate in suitable seams down to 3 ft. in thickness, and it is confidently anticipated that, as more experience is gained, there will be still further developments which will overcome the natural difficulties for which a solution has not been found so far.

There are many other developments of which I could speak if time permitted: the coal plough, which was originated in Germany, and wedging machines and slabbing machines which are being developed over here. I have sought, however, to give some brief explanation of those machines and methods which are now being employed in the mechanisation of coal-getting operations in Great Britain. As I have already indicated, power loading is still in its infancy in this country, and so it is not possible to show its effect, on a large scale, on the industry as a whole. By the end of 1946, over 100,000 tons of coal a week was being loaded by power loaders but, of course, this only represents about 3 per cent. of the output of the country. Nevertheless, it shows a very pronounced increase over, say, the previous three years. At the beginning of 1944, approximately 15,000 tons of coal a week was being loaded by power loaders; 10,000 tons from room-and-pillar work and 5,000 tons from longwall work. At the end of 1946, 70,000 tons a week was coming from room-and-pillar work and 45,000 tons a week from longwall work. The technical possibilities of power loading have been established and, as mining conditions can be adjusted, personnel trained, and more machines put to work, its influence on the efficiency of the industry will be more clearly felt. In certain aspects, the mining industry in this country presents a dismal picture to-day, but never in my experience has there been so much activity and effort directed towards the improvement and advancement of mining methods. This, I would submit, is at least a hopeful and encouraging sign for the future of this basic industry.

The Institute of Welding (South London Branch).—The next meeting of the South London Branch of the Institute of Welding will be held on Thursday, November 6, when Mr. R. R. Sillifant will read a paper on "Argon Arc Welding," at the Wandsworth Technical Institute, High-street, London, S.W.18. "Welding in Marine Engineering," is the subject of a paper by Mr. J. A. Dorratt, which will be given on December 11, at the Institute of Marine Engineers, 85-88, The Minories, London, E.C.3. Tickets for these meetings and further particulars may be obtained on application to the branch secretary, Mr. E. F. Burford, 99, Kidbrooke-grove, Blackheath, London, S.E.3.